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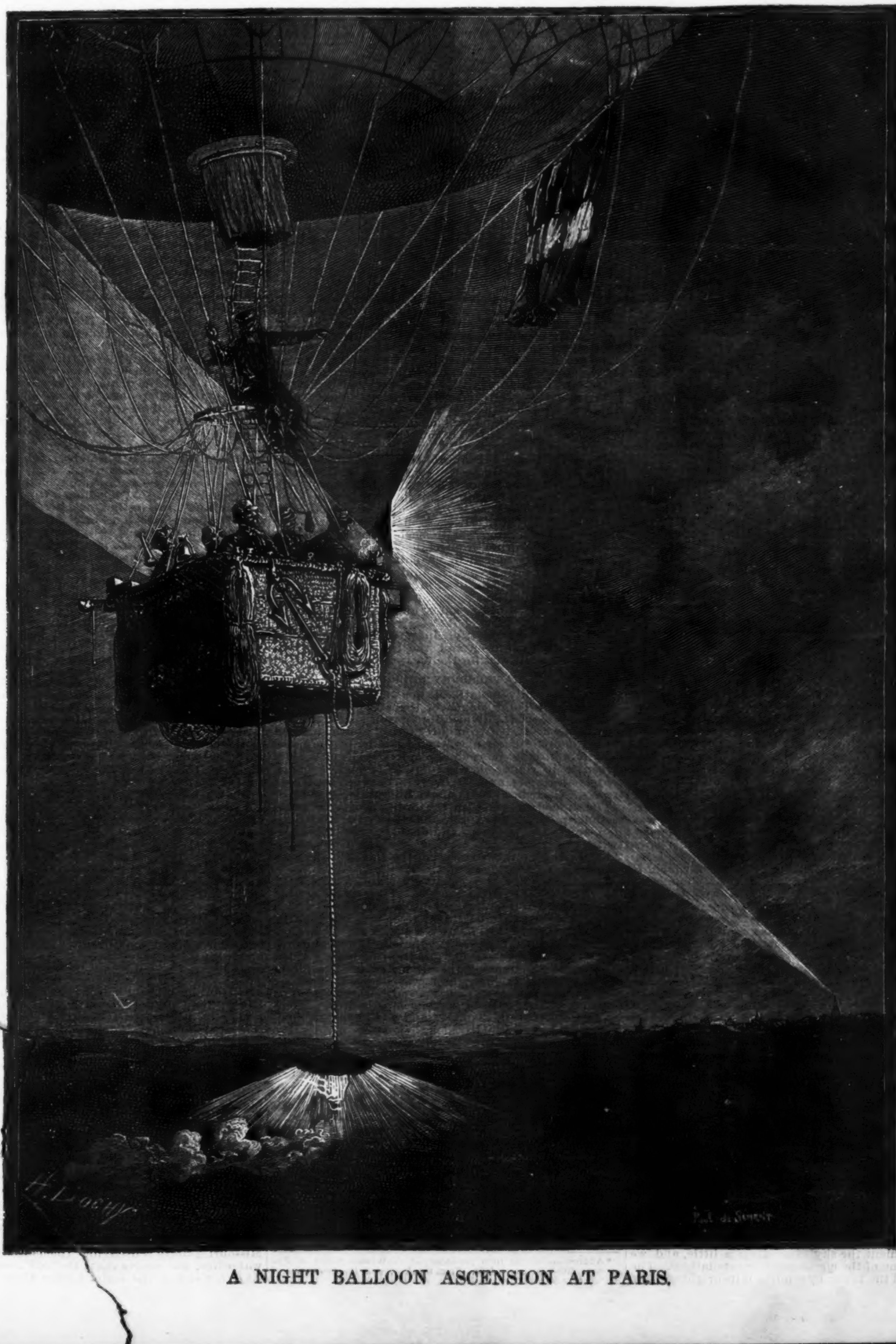
A NIGHT BALLOON ASCENSION.

MR. EIFFEL having placed special cars at our disposal, Messrs. Gabriel Yon, Triboulet, Corot, Paries, Vernauchet, Richard, and a few other aeronauts and ourselves entered the elevator of the northern pillar of his tower on the 26th of June, at a quarter past eight in the evening. We ascended to the belvedere of the third platform in order to make an experiment of the highest scientific and patriotic interest, our intention being to watch, during its motion in the air, an electric lamp that the Figaro was to light during the course of the ascension that it was to make at nine o'clock sharp at the Vilette Gas Works. We wished to be convinced that it was possible to observe this



A NIGHT BALLOON ASCENSION AT PARIS.

new star with sufficient precision to permit of a subsequent establishment of a nocturnal telegraphic communication between the tower and a balloon traversing the horizon of Paris.

How many thoughts were aroused by this tentative! The balloons of the siege of Paris, the splendors of the universal exposition, our regrets and hopes, the time that is no more and that of which Providence guards the secret.

Overhead, the sky was covered with a compact stratum of cumuli close pressed against each other, fused into a vault that occupied the entire extent of the firmament. Having reached its tenth day, the moon was already bright, and it was still very high, as it had passed to the meridian scarcely two hours before.

Still, none of its rays reached us, and not a gleam betrayed its presence. But, as it had been agreed upon that Mr. Jovis should not ascend beyond 1,000 meters so long as he should see the lights of the projectors, we were certain that the Figaro would not get lost in the darkness.

However, the light was still very strong, and the deep shadows that had descended upon the city, where they lay like a crape veil, had not yet had time to reach us. We at once telephoned to have the inflating arrested for half an hour, and we also asked to have rockets fired in order that we might direct our projectors toward the works, whose bearings we had lost, since the lights were still too few in number to allow us to recognize the geography of Paris by the form of the constellations of gas burners and arc lamps which trace the contour of its different streets in so enchanting a manner.

Some rockets soon showed that our messages had been understood. Mr. Milon directed the fire of his luminous artillery upon the point signaled, without any suspicion of the perturbation that the setting off of the fireworks and the unexpected arrival of the dispatches coming directly from the tower caused in the crowd that had overrun the yard of the gas works.

At 9 h. 20 m., the Figaro began its ascent. Scarcely had it left the earth when our rays flooded it with their very bright light. We soon distinguished a Bengal light burning beneath the car, and its purplish reflections astonished us by their richness and intensity. How many thousands of Parisians were gazing at the heavens!

Spectators in incalculable number were grouped upon Chaumont and Montmartre hills. At this moment, as many eyes were directed toward the Figaro as were perhaps directed toward the sun at the time of the eclipse of June 17, with the difference, however, that the spectators did not need this time to smoke pieces of glass in order to contemplate the celestial phenomenon. Those who had been prudent enough to provide themselves with opera glasses had an opportunity of enjoying the scene that our artist has here depicted from nature.

Mr. Jovis had seated himself upon the ring, and Mr. Mallet had his hand upon the reflector, with which he concentrated the electric rays in the direction of the tower.

At this moment, Messrs. Girod, Vernes, Oberkempt, and Hartmann, the four passengers, were dazzled by the combined rays of our two projectors. In fact, we literally flooded the Figaro with a torrent of light. Meanwhile, when the aerial travelers cast their eyes toward the earth, they saw, as we did, the electric lights and the interminable rows of gas lamps that mark the boulevards, streets and squares opening to view at their feet. The candelabras of the quays and bridges especially attracted their attention, because of the magic reflections produced upon the silvery mirror of the Seine.

They heard, better than we did, a loud clamor that arose to them from the crowd. Insensible to all this, the Figaro saw only the tower and the refulgence of our electricity, and its flight was directed toward our platform. According to the Richard anemometers, it was approaching with a velocity of eight meters per second, and we began to ask whether it was not going to reach us by accident.

Mr. Jovis having sacrificed a little sand, the Figaro gradually disengaged itself from the current in which it was immersed, and going off toward our right, took a direction more and more to the east. The lamp had a brilliancy equal to that of Sirius, which adorns the winter sky only. Its luster soon became less than that of Mars, which was traveling in the opposite part of the heavens, and which the clouds, moreover, completely hid from view. The star of the Figaro was the only one shining in the firmament, since the sky was overcast, but it possessed a peculiar color, a special tone. Among all the constellations, it would be impossible to discover a single body with which it could be confounded, were the night clear enough to allow the firmament to display all the wealth of its celestial casket.

The lamp disappeared for the first time toward 10 o'clock. At exactly 10 o'clock, as had been agreed upon before the start, the Figaro ignited a second Bengal light, which permitted of finding it again without delay. At 10 h. 10 m. there occurred another eclipse, which lasted several minutes. Between Meaux and Crecy the Figaro had been enveloped in one of those numerous clouds that were traveling with it, driven along like it by a moderate wind, and whose direction, like its own, turned more and more toward the east. As soon as Mr. Jovis felt that he had got out of this annoying cloud, he projected his third light in order to guide the telescope, and consequently the projectors. The rays, which were exploring space without success, immediately pointed in the proper direction.

At 10 h. 37 m., a Bengal light was seen detaching itself from the bottom. It was a dispatch sent by Mr. Jovis.

A large number of visitors had been crowding around us for some time, and we were no longer alone upon Mr. Eiffel's terrace. The cars had brought from the first platform a large number of pupils of the Central school, to whom Mr. Eiffel did the honors of his incomparable aerial villa. Refreshments and cigars were distributed, dances were organized, and trumpeters were installed above the beacon.

At this moment the sky cleared up a little, and we perceived some of the circumpolar constellations. The moon saluted the tower by sending it its brightest rays.

Some of Mr. Eiffel's invited guests and himself kept watch of the Figaro, which was all the time soaring away. The lamp kept on diminishing, but we did not lose sight of it till 11 h. 30 m. The balloon had then got beyond Chateau-Thierry. All its evolutions, save those during the two interruptions that we have mentioned, had been watched for two hours and a quarter. Some others of very short duration took place toward the last, but they were of an entirely different nature. Mr. Mallet conceived the happy idea of masking the rays of his lamp, and we saw very well that something extraordinary was going on, and attributed these extinctions to a gyrating motion; that was the most natural explanation in the ignorance in which we were in regard to this important experiment. But the interruptions that will be produced hereafter will be much better defined with a Morse key. Their rhythm, moreover, will permit of recognizing them in an infallible manner.

This success is so much the more encouraging in that it was obtained on a very unfavorable night, amid the preparations that were making for a torrential rain, which fell at Paris at about two o'clock in the morning, and overtook the aerial travelers after their descent.

The tricolored beacon was perceived by the aeronauts up to half past one in the morning. Then the Figaro was entering a cloud beyond Epernay. Those in the balloon had known for two hours that we were no longer watching. The extinction of the projectors had given the balloon the liberty of bounding in the heights of the atmosphere much above the thousand meter limit.

The cloud that the Figaro entered was an immense one. It was more than 1,200 meters in thickness, according to Mr. Jovis, to whom, for want of space, we regret that we cannot give way in order to hear from him an account of the end of this remarkable voyage, which will mark a stage in the progress of aerial navigation.—*Le Monde Illustre.*

[Continued from SUPPLEMENT, No. 761, page 12154.]

SOME ENGINEERING WORKS.*

By E. L. CORTHELL, Member Western Society of Engineers.

THAMES RIVER BRIDGE.

New London, Conn., on line of N. Y., P. and B. Railway.

This structure is principally noted for having the longest double track draw span in the world—503 ft. between centers of end piers. The maximum depth of water at the crossing is some 57 ft. The distance from low water to the bottom chord of bridge is 38 ft. The piers are founded on piles driven at deepest point through more than 70 ft. of mud and clay into a gravel bed. The total length of bridge between centers of abutments is 1,423 ft., made up of two spans 310 ft. each, two spans 150 ft. each, and a draw span of 503 ft. The spans are arranged symmetrically about the pivot pier draw. The principal dimensions of which are as follows:

The width center to center of trusses, 28 ft. 4 in.; end height between centers of chord, 25 ft.; center height between centers of chords, 71 ft.; the distance from base of rail to masonry on pivot pier is 19 ft 1 in. The diameter of turntable is 32 ft. and is rim-bearing. There are 58 cast steel wheels 20 in. in diameter and 10 ft. face and weighing 800 lb. each. The load is distributed to the drum from eight equidistant points. The weight to be moved in swinging bridge is about 1,300 tons. The draw span is equipped with a double oscillating engine 10 in. by 7 in. stroke. The average speed is 175 revolutions per minute. The end arrangement runs out in 15 seconds, and the draw can be opened in 2½ minutes.

Mr. Alfred Boller, civil engineer, of New York City, was the chief engineer, and the Union Bridge Company had the contract for the entire structure.

HAWKESBURY BRIDGE.

This is specially remarkable for the great depth of foundations. Total length of the structure between abutments, 2,896 ft., divided into seven spans, the end ones being 408 ft. between outer face of abutments and center of first regular pier, the remainder of the spans being 416 ft. between centers of piers. All spans 410⅛ ft. center to center of end pins, 58 ft. high between centers of girders, and 28 ft. wide between centers of trusses. Clear head room above high water is 40 ft.

The superstructure is of the ordinary double intersection, quadrangular, pin-connected type. The spans were erected on pontoons and floated into position between the piers, being located over the piers at high tide, when span floated clear; as the tide fell, the span rested upon the bridge seats.

The caissons for the piers were elliptical and 24 ft. by 62 ft. at the cutting edge. They were settled through mud and sand strata into a bed of hard gravel which is about 126 ft. below the river bed, 185 ft. below high water, and 227 ft. below the track on the bridge. The caissons were sunk by dredging through three tubes 8 ft. in diameter, terminating in bell-mouthed expansions which met at the cutting edge. The filling of the caissons to low water was made of concrete; above low water cut stone masonry was used. The piers above the concrete portion consist of two circular columns 14 ft. in diameter and 28 ft. apart, centers connected by a wall 6 ft. thick.

The caissons were sunk as follows:

Pier.	Low Water to River Bed.	Depth below River Bed.		Total Depth below Low Water.		Total Height of Pier.	
	Ft.	Ft.	In.	Ft.	In.	Ft.	In.
Pier I........	38	55	8	93	8	195	8
" II......	40	108	1	148	1	190	1
" III......	43	96		139		181	
" IV......	21	118	6	129	6	181	6
" V......	19½	117	5	136	11	178	11
" VI......	47	108		155		197	

Pier VI. in sinking 80 ft. got out of position, moving toward the shore and endwise. A load of rock was dumped in on the shore side, the caisson forming a fulcrum. Heavy cables extending to shore were used to draw the top of the caisson in, that is, toward shore, thus throwing the stone out. These appliances succeeded in drawing the caisson into its proper position before reaching its final resting place. The total cost of bridge proper as per contract was $1,654,800. The time allowed for building was two and one-half years. The Union Bridge Company had the contract for the entire structure.

FIRTH OF FORTH BRIDGE.

Designed and built by Messrs. Fowler & Baker, chief engineers.

At the point where it crosses the Firth the water is 200 ft. deep in places, making use of staging impossible. Violent storms are also of frequent occurrence.

The total length of structure is about 1½ miles. The main bridge is made up of three immense cantilever spans connected by short suspended spans. The approaches are made of ordinary lattice girder spans 168 ft. in length.

There are three main piers, the Fife, Inch Garvie, and Queensferry piers. Each main pier is made up of four smaller piers or columns of granite-faced masonry. The height of these small piers or columns is 36 ft., diameter 55 ft. at the bottom and 49 ft. at the top. Each of these piers contains 48 steel bolts 2½ in. in diameter by 24 ft. long for anchoring the structure.

Part of the foundations below low water was put in by use of open dams, and part of them by the pneumatic process. Two of the Inch Garvie piers were located where there was a depth of 72 ft. at high water and where the bottom was rough and sloping. The sloping bottom was leveled up with bags of sand to give caisson an even support. The rock was then taken out and caisson lowered until it reached a full level bearing on rock.

At Queensferry all four piers were founded upon caissons sunk to bed rock or into a hard bowlder clay bed overlying the rock. The greatest depth below high water was 89 ft. The time required for placing all the caissons was about two years. The greatest air pressure used was about 35 lb. In all the work of sinking caissons there were no deaths of workmen attributable to working under heavy air pressure.

The superstructure of main bridge consists of two cantilever spans 1,710 ft. in length each and two spans 675 ft. each (being the shoreward arms of cantilevers).

The approaches are made up of spans 168 ft. each. The middle or suspended spans are 350 ft. each in length, included in the 1,710 ft. above noted. These suspended spans are 50 ft. deep at center and 41 ft. at the ends. Their weight is about 896 tons each. One end is fixed to the cantilever arm and the other end is movable for expansion. The spans connecting the four columns of the main piers, which may properly be called towers, are, two of them, about 150 ft. each, the third being some 265 ft.

The distance from water surface to tops of main towers is 360 ft. The clear head room under the center of bridge is 152 ft. at high water. The tower columns are 120 ft. apart at base and 35 ft. apart at the top. One of the 1,710 ft. spans weighs about 17,000 tons. The heaviest rolling loads known only make about 900 tons, or say 5 per cent. With assumed wind pressure of 56 lb. per sq. ft., the estimated lateral pressure on each 1,710 ft. span is 2,240 tons, or 2½ times as much as the rolling load.

The main compression members are cylindrical tubes, as that form gives the greatest strength with the least weight. The largest tubes are 12 ft. in diameter, the shell being about 1¼ in. to 1⅞ in. thick. Each cantilever tube is subject to a pressure of 2,555 tons from dead load, 1,145 tons from live load, and 3,270 tons from wind. The tension members are similar to our ordinary heavy latticed structures, being composed of plate and angle sections, and being formed into trusses having top and bottom chords which are about 12 ft. apart in the maximum.

The lower parts of bed plates on the piers are made up of several steel plates riveted together; the weight of this lower plate is nearly 45 tons. The upper part of bed plate is left free to slide over the lower or rigid portion. The former portion forms part of the base of the skewback. The plates of cylindrical columns are bent into shape while hot by a bending press, the rams being capable of exerting a pressure of 1,780 tons. The plates had an extra squeeze given when nearly cold to prevent their twisting.

The erection of the cantilever spans was commenced at the piers and worked both ways. All the rivets in the tube are machine driven, the machines being hydraulic and weighing nearly 18 tons each. At times 800 good rivets were driven per day of ten hours at a height of 300 ft. above high water. The estimated number of rivet holes in the large cylindrical compression member is 5,000,000.

The approach girders were erected on piers when only a little distance above the ground. They were then raised by hydraulic jacks, several spans at a time, and stonework was built up underneath in steps of about 3½ ft.

ST. LOUIS MERCHANTS' BRIDGE.

This bridge is being built by the St. Louis Merchants' Bridge Company for the purpose of affording a competing line across the Mississippi River at St. Louis. It is located about two and one-half miles above the Eads' bridge, and connections are made with the various railroads on each side of the river. The river is spanned by three independent trusses of steel, each truss being about 520 ft. long.

The bridge is a double track structure 52 ft. above high water in its center and about 50 ft. at the ends of the bridge. The total length of the permanent steel and masonry bridge is 2,420 ft. The river at the bridge site is reduced to a width of about 1,660 ft. by means of a permanent dike on the bridge approach and by a brush dike 1,000 ft. above it.

It was not necessary at this bridge to go to so great a depth as at the old bridge to reach the bed rock, which is nearly level at this point, and is at an average depth of 46 ft. below low water. The bridge is built on pneumatic caissons 70 ft. long and 26 ft. wide for the shore piers, 70 ft. long and 28 ft. wide for the two river piers. Missouri granite is used for the masonry to the high water line, and above that Bedford limestone is used. At either end of the main bridge there was about 425

* Address on retiring from presidency of the Western Society of Engineers. Read January 8, 1890. From the *Journal* of the Association of Engineering Societies.

ft. of deck spans with viaducts and spans over streets and the railroads. All of the structure is of steel.

The consulting engineer of the bridge is Mr. Geo. S. Morison, member of the society, who has designed the superstructure, the chief engineer is Mr. E. L. Corthell, member of the society, and the resident engineer in entire charge of the work is Mr. H. W. Parkhurst, also member of the society. The contractors for the entire main bridge and 425 ft. of the permanent approaches are the Union Bridge Company, of New York. The superstructure of this bridge, as well as of the Cairo bridge and of several other large bridges of a similar character, has been erected by Baird Brothers, who have been very successful in their work in every instance.

The St. Louis Merchants' bridge has probably been built in the shortest time of any bridge over the lower Mississippi River, and, perhaps, in the shortest time of any bridge of its magnitude. It has practically been built within one year's time. The last of the main spans is erected.

MEMPHIS BRIDGE.

This bridge is now being constructed over the Mississippi River at Memphis, Tenn. The chief engineer of the bridge is Geo. S. Morison, and the resident engineer Mr. Alfred Noble. The bridge will be principally remarkable for the length of its three main spans, which are, beginning on the Memphis side, respectively 790 and two 621 ft.

The continuous superstructure will consist of a central span (resting on piers II and III) 621 ft. ½ in. long, from each end of which will project a cantilever arm, 169 ft. 4½ in. long; of an anchor span (from the anchorage pier on the Tennessee shore to Pier I), 225 ft. 10 in. long, from which will project a cantilever arm precisely like those projecting from the central span; of two intermediate spans 451 ft. 8 in. long (one of which will be suspended from the cantilever arms projecting from Piers I and II, and the other will be suspended at the east end from the cantilever arm projecting from Pier III, and will rest at the west end on Pier IV), the entire continuous superstructure being 2,258 ft. 4 in. long, divided into one span of 225 ft. 10 in., one of 790 ft. 5 in. and two of 621 ft. ½ in.

This continuous superstructure will be rigidly fastened to Piers I, III, and IV, but will rest on expansion rollers on Pier II. Slip joints will be provided for expansion at the suspended ends of the independent spans.

The trusses will be placed 30 ft. between centers, and will be divided into panels 28 ft. 2¾ in. long, the right being reserved to shorten the panels by an amount not exceeding ½ in. at any time before the work is actually manufactured.

The deck span at the west end will be 338 ft. 9 in. long from the center of Pier IV to the center of the pin on Pier V, divided into 12 panels of 28 ft. 2¾ in. each, the trusses being placed 22 ft. between centers. The east end of the span will be carried in niches on the west side of Pier IV; the west end will have roller bearings over the center of Pier V. This span will include a vertical bent which will carry the west end of the west pair of stringers.

The estimated approximate weight of the continuous superstructure is 13,000,000 pounds; that of the deck span 1,000,000 pounds, making the total estimated weight of the superstructure of the bridge proper 14,000,000 pounds.

The caisson for Pier I, which is located between the high and low water lines on the Tennessee side of the river, is to be 308 ft. by 70 ft. and 53 ft. high, the plan being similar to those of the channel piers at Cairo. It is to be sunk 45 ft. below low water. Caisson for Pier II is 47 ft. by 92 ft. and is 60 ft. high, to be sunk 94 ft. below low water. Caisson for Pier III is 47 ft. by 92 ft. and 40 ft. high, to be sunk 80 ft. below low water. For Pier IV it is 26 ft. by 60 ft. and 50 ft. high, and it is to be sunk 60 ft. below low water. Caisson for Pier V will be 22 ft. by 40 ft. and probably 80 ft. high, and will be sunk 55 ft. below low water. The character of the foundation on which these piers will rest is: first, a light clay reaching to a dark blue hard clay which, no doubt, will be of ample consistency to bear the weight of the structure.

EIFFEL TOWER.

As preliminary to the brief description of the Eiffel Tower, the following extract from London *Engineering* will show what a complete failure, architecturally, at any rate, was predicted, and what a complete success was realized by the design and construction of this remarkable monument to the genius of a civil engineer:

"On the 5th of November, 1886, the Finance Committees of the Paris Exhibition voted a credit of 1,500,000 francs as a subsidy for the unique and monumental work M. Gustav Eiffel had undertaken to construct, and which was to be one of the great original features of the exhibition. The idea of erecting a tower 1,000 feet in height was received with a very general feeling of distrust and even of dismay; not that any one doubted the capability of the bold and successful engineer to complete the work to which he had pledged himself, but the misgivings were very general as to the effect such a novel construction would have upon the architectural features of the exhibition, and the widespread cry of influential voices went up from Paris as a protest against the engineering outrage that was to be inflicted upon the French metropolis. It is rather curious, now that the tower is completed, and the great consensus of public opinion is loud in its approval, to recall the remonstrance addressed to M. Alphand, the director general of the works, against the proposed column. 'We wish authors, painters, sculptors, architects, enthusiastic lovers of beauty which has hitherto been respected in Paris, to protest with all our energy, and with all the indignation of which we are capable, in the name of art and of French history now menaced, against the erection in the heart of our capital of the useless and monstrous Eiffel Tower, which public satire, often full of good sense and a spirit of justice, has already christened the Tower of Babel.'

"Is the city of Paris to permit itself to be deformed by monstrosities, by the mercantile dreams of a maker of machinery; to be disfigured for ever and be dishonored? For the Eiffel Tower, which even the United States would not countenance, is surely going to dishonor Paris. Every one feels it, every one says so, every one is plunged into the deepest grief about it, and our voice is only a very feeble echo of universal opinion properly alarmed.

"To this vehement protest was attached the names of many of the best known men of France: Meissonier, Gounod, Garnier, Sardou, Gerome, Bonnat, Bouguereau, Dumas, Coppee, etc. But these well-meant, ill-judged remonstrances were not heard, and to-day the Eiffel Tower stands completed, the marvel of the exhibition and the glory of the constructor. The noble monuments of Paris apparently thrill as much as they did before with the genius of the centuries, and the grand proportions of the Arc de l'Etoile do not seem to have suffered because a great French engineer has achieved a triumph of construction."

Active work on the foundations was commenced in Jan., 1887, after a very careful investigation of the ground, had been made in ascertaining the nature of the foundation upon which the structure was to rest. A large number of borings were taken on the Champ de Mars, showing that there was a bed of hard, compact clay about 52 ft. in thickness resting upon the chalk formation, enabling it to carry with safety from 3 to 4 tons per square foot.

There are four independent foundations, each standing at one angle of a square, about 330 ft. on a side. The gravel on one side was met at a depth of 23 ft. below the surface, and the thickness of it was 18 ft. The piers are built upon a bed of cement concrete 7 ft. in thickness. The other two piers nearest the Seine were in different material; the bed of sand and gravel was 40 ft. below the surface, that is, 16 ft. below the mean level of the Seine, and was overlaid by soft deposits. Work was performed by means of caissons with compressed air to a depth of about 52 ft. The caissons were of iron, 49 ft. long and 20 wide. On this concrete were built masonry piers. Each one was built with one face vertical toward the center of the tower, the outer corresponding face being inclined at the same angle as the column of the tower. The two other faces are vertical and parallel. The top of the pier is at right angles to the back face, and therefore normal to the springing of the column. The total load which each of the piers on the two foundations nearest the Champs de Mars has to carry is 1,970 tons, and the load on the masonry is equal to about 3 tons to the square foot.

In reference to the superstructure the leading principle followed was that adopted by M. Eiffel in all his elevated structures, namely to give to the angles of the tower such a curve that it should be capable of resisting the transverse effects of wind pressures without necessitating the connection of the members forming these angles by diagonal bracing. The Eiffel Tower therefore consists essentially of a pyramid composed of four great curved columns independent of each other and connected together only by belts of girders at the different stories until the columns unite toward the top of the tower, where they are connected by ordinary bracing. Iron, and not steel, was used in the construction throughout.

The tower terminates at a height of 896 ft. above the ground, with a platform about 53 ft. square. The width of the column at this level is 33 ft., the gallery being carried by brackets. Above the platform rises the campanile. In the lower part of this is established a spacious and very complete library, closed to the public, and intended for the prosecution of scientific research and observation. Four latticed arched girders rise diagonally from each corner of the lower part of the campanile and unite at a height of about 54 ft. above the platform; by means of a spiral staircase yet another gallery is reached about 19 ft. in diameter and surrounding the lantern which crowns the edifice and brings the height of the structure to 984 ft.; above this rises the great lightning conductor. The area of the first story, which is mostly devoted to restaurants of various nationalities, is 38,000 sq. ft., the second floor has 15,000 sq. ft. Elevators of various kinds take one from one story to the other to the top of the tower. The complete success attending the construction and the erection of this tower and of the many appliances which belong to it makes it a marvel of engineering skill.

MISSISSIPPI JETTIES.

The greatest achievements of our profession are not always those which appeal to the eye. What we work for in our profession are results for the good of mankind. If we can combine with our bridges which cross the great rivers lines of beauty, so much the better, but there are certain works built for commerce and whose benefits to the human race are almost incalculable which to the eye have no lines of beauty, are rough and unhewn as it were, and yet are so substantial as to endure the greatest servitudes of the sea, and all so well planned both in location, materials of which they are composed and in general design as to accomplish results which are very far reaching in their effects. This is the case of the Mississippi River jetties. The beautiful bridge which spans the river at St. Louis is a monument to the genius of the engineer that conceived and built it, but the jetties built of willow brush and broken rock, covered with the muddy deposits of the Mississippi River, overgrown with rank grasses and by the drift logs which the currents bring from the uplands to the Gulf, are a greater monument to the genius of the same engineer. The rough works have become the gateway of a continent; they have now for more than a decade stood boldly and successfully against the onslaught of the waves and the undermining of the currents; and it is a satisfaction to know that the work was conceived and executed by a civil engineer in the face of the most pronounced and decided predictions of utter failure. It is a satisfaction still more to state to-night that after the passage of ten years of time the channel which was carved through the obstructing bars by these works is deeper and wider and more adequate than ever for the commerce which passes through it. It is now a common thing for heavily laden vessels drawing from 26 to 27½ ft. to pass through the jetty channel without any detention. Formerly, before these works were commenced, there was a depth of water about 8 ft. on the South Pass bar, and commerce was continually striving to pass through an artificial ditch kept open by a dredging machine at the mouth of the Southwest Pass. It is not intended now to give a description even of these works. They are matters of history, and every engineer knows more or less about them and how they were built. Rough mattresses of willows as a foundation, these covered with stone to hold them in place until a heavier concrete capping could be put upon them; one jetty extending 2½ miles from land into the Gulf, the other 1,000 ft. from it and parallel to it. These main jetties were covered with concrete blocks, some of which at that time were the heaviest that had ever been built in a seaway, the outer blocks weighing 181 tons. The main portion of this work has never been disturbed by the elements. One of the views thrown on the canvas will show the concrete wall which has within the last year been built on the original concrete blocks; another view will represent an inner jetty about 150 ft. from the line of the main jetty, built for the purpose of causing the inclosed area to be filled by deposit from the river and the waves, and to prevent the washing of sand into the channel by the waves as they come over the main jetty in times of storm. The available width of navigation between the inner jetties is about 700 ft.

One of the most difficult undertakings connected with the entire work was the controlling of the channels and currents of the main river at the head of the passes 12 miles above the jetties. It was considered by Col. W. Milner Roberts that this was the most difficult engineering work in river hydraulics which the world has ever seen, far exceeding the difficulty met with at the mouth of the pass; for at the latter points it was simply a question of guiding the currents out of the pass into the Gulf; at the head of the passes, however, the problem was how to maintain the currents into the small pass, carrying only about ten per cent. of the flow of the river, while the two wide passes on either side its main volume to the sea, and that too flowing over a river bed that was almost as movable as the water itself. Without going into a description of these works, we will simply say that the river in its entire volume and its great width of a mile and three-quarters, 30 ft. deep, with a strong current, was bridled by cheap, rough mattresses laid as sills upon the beds of the great passes and guiding and holding the volume of water into South Pass as required, deepening the bar at its head from 15 to 40 ft.

Perhaps the greatest honor that has ever been conferred upon an American engineer was bestowed upon the author and constructor of these great works. The Society of Arts of Great Britain presented to Mr. James B. Eads the first of the Albert medals ever given to an American citizen for his great works in opening and improving the water communications of North America.

CHIGNECTO MARINE RAILWAY.

For many years an indefatigable civil engineer has been at work promoting a marine railway project for connecting the waters of the Bay of Fundy with those of the St. Lawrence across the isthmus of Chignecto, by which 600 miles of troublesome, dangerous and expensive navigation will be saved by taking vessels over land a distance of 17 miles. All of the coastwise business coming out of the St. Lawrence River destined for New Brunswick, Maine, and ports farther south will take advantage of this shortened route when this work is completed. The line will be perfectly straight, the grades 10 ft. to the mile, the size of the hydraulic lifting docks will be 235 × 60 ft., the length of the hydraulic rams 40 ft., the width of the roadbed 40 ft., the gates 60 ft. wide at the sea level. The railway will consist of a double track road of four rails, the weight of rails being 110 lb. per lineal yard, many of which are already rolled and on the grounds. The length and width of the largest carriage will be 210 × 40 ft., in three segments. The lifts will be capable of lifting vessels of from 2,000 to 2,500 tons displacement weight, and it is expected that it will require but 2½ hours' time to pass from the Bay of Fundy to the opposite water—the Bau Verte.

According to the rates which have been determined upon, a vessel of 1,000 tons register will pay $750 as its fare across the isthmus. It will be cheaper to pay this sum than to make the 600 mile trip around Nova Scotia. The Canadian government in its desire to promote a passage across this isthmus has guaranteed for 20 years the interest on an investment of $5,000,000.

When this railway is built (and it is now under active construction, with the expectation of being put into operation within a year), the practicability and the commercial advantages of a ship railway will be demonstrated by a model of very large size; in fact, the success attending this primary work will no doubt lead in the near future to the building of similar works and on a larger scale in many parts of the world where the natural conditions are not favorable to canal construction or navigation, notably across the American isthmus, across the peninsula of Florida, between Georgian Bay and Lake Ontario, between Rock Island on the Mississippi to Hennepin on the Illinois River, and at many other points where the natural conditions prevent the economical construction of waterways.

The resident engineer of the Chignecto Marine Railway, and to whom the project is no doubt most largely indebted for its realization, is Mr. H. G. C. Ketchum, a civil engineer of New Brunswick. The chief engineers who are designing and building the mechanical appliances and have general charge of the work are Messrs. Fowler & Baker, the chief engineers of the Forth Bridge. The fact that such men as these have charge of this work is a surety of complete success.

TEHUANTEPEC SHIP RAILWAY.

The last conception and project of Mr. Eads, of whom we have already spoken as the designer and builder of the bridge over the Mississippi River at St. Louis and of the Mississippi jetties, was that of a ship railway across the American isthmus at Tehuantepec, in Mexico. It may be of interest to state that when, after four years of constructive work at the mouth of the Mississippi, and after seeing what the grand commercial result of these works would be, his thoughts naturally tended to how to give to this same commerce an outlet into the Pacific Ocean. It was not a submerged bar easily moved by currents directed against it by well designed jetties, but the great backbone of a continent which stood in the pathway of commerce. He said to himself, "If we cannot remove this obstruction, let us surmount it," and immediately set at work designing, while at the mouth of the Mississippi River, a railway that would carry heavily laden ships across the isthmus. That was in 1878, and from this time until his death in 1886, he was constantly at work, either here or in Europe, upon this great project. He had an unswerving faith in it and an entire confidence of complete suc-

cess, and gave to this work all of that marvelous ingenuity of which he was possessed. Since his death his co-workers have not been idle, but have been at work perfecting the plans and endeavoring to secure that large financial aid which is necessary to carry out a project involving from 60 to 75 million dollars.

NEW ORLEANS BRIDGE.

It was not many years ago that it was thought impracticable to build a truss span 500 ft. in length, and there was a vigorous discussion on that subject in reference to a proposed bridge at St. Louis. Since then many such spans have been built, and they are now turned out as standard plans, as it were, and placed across many rivers. At Memphis, where the navigation interests and the U. S. government demanded a span 770 ft. clear length, the engineer rose to the occasion and planned it and is now building it.

It is now proposed to bridge the Mississippi River at New Orleans below all of its tributaries and where its volume has carved a deep permanent channel in the alluvial lands of the Delta. The demands of navigation and of the government are still more severe here than they were at Memphis, and nothing is permitted in the way of spans less than 800 ft. in the clear or less than 75 ft. in height for the steamboat navigation and 82 ft. for the great naval cruisers of the U. S. government.

The river is half a mile wide, and it is boldly proposed to throw a bridge across this river with only two piers in the river bed, making the three spans independent, each 866 ft. in length, a double track steel bridge with steel approaches. This bridge will connect the Texas & Pacific and the Southern Pacific R.R.s on the west with four main lines on the east, and will permit these western roads to enter the city of New Orleans from the rear and to reach a union depot which it is proposed to build in the heart of the city in connection with a belt road connecting all of the railroads. The bridge in many respects will be exceptional. It will be founded in the alluvial bed of the Mississippi River, where there is no bed rock and where the foundations must be broad enough to not have placed upon them more than 3 or 3½ tons per sq. ft. It is proposed to erect the spans on floating pontoons similar to those employed at the Hawkesbury bridge, New South Wales, where spans over 400 feet were floated quite a distance and put in position by this means. The plan of the bridge may, however, be modified radically by building a continuous girder on the principle of that already described of the Britannia bridge, and similar also to that proposed for a high bridge across the Detroit River, where the conditions as to width are very similar to those at New Orleans. The engineer of this bridge project is Mr. E. L. Corthell.

DETROIT RIVER BRIDGE.

In 1874 Mr. James F. Joy, then president of the Michigan Central R.R., during a contest with the river interests in reference to the bridge at Detroit, stated that the world would not forever stand still on the banks of the Detroit River. It has stood still about fifteen years since that time, but now the world is in a fair way to move across. The business since 1874 has very greatly increased between the East and the West, and particularly at this point. The obstacle to the free, economical, and uninterrupted navigation across this river is the severe winters, accompanied by heavy ice, which makes the crossing difficult and diverts during the winter from this route much of the travel that naturally belongs to it. Various plans for a bridge have been proposed, but the interests of navigation are so important that any kind of a bridge but a high bridge, high enough to allow the tallest mast to go under it, and wide enough to not present any material obstruction to the movements of commerce, is absolutely necessary and is imperatively demanded by the vessel interests.

Mr. Gustav Lindenthal, a civil engineer of reputation and ability, has proposed and made the design for a bridge with only two piers in the river, with a clear height of 135 ft. at the piers and at the middle of the bridge of 140 ft.; the middle span is to be 1,020 ft. in the clear, the side spans 700 ft., the towers nearly 300 ft. high, the approaches about 1½ miles long. The bridge will be a continuous girder resting on four piers, the height of the superstructure being uniformly 120 ft. high, the entire length of the bridge. It is intended to erect the side spans of this bridge first on false work or by pontoons, and then to erect the central span without false works, using the side spans as cantilevers to hold up the weight of this central span.

NORTH RIVER BRIDGE.

Various plans have been proposed for crossing the North River at New York City. One of these is by a tunnel which has been for several years under construction. This will be a double track tunnel. A bridge has been proposed high enough to allow ocean navigation to pass under it, and with one pier in the center of the river. The best design, however, and one which no doubt will meet with the least opposition from the navigation interests and from the government, is that of Mr. Lindenthal who has proposed a bridge without a pier in the river. The river at the point where the bridge is proposed to be built is about 2,850 ft. wide. The bridge will be a stiffened suspension bridge with a main or middle span 2,850 ft. long and side spans of 1,500 ft. each; the height above the water will be 155 ft., total length of the bridge 6,500 ft., the height of the anchorages 210 ft., the height of the towers above the water 500 ft., and the deepest foundations below high water 190 ft.

The bridge is to have from six to ten tracks. There will be four cables used, each of which will be 48 in. in diameter, the area of which will be about ten times that of the Brooklyn bridge, the latter being 15¼ in. in diameter; the width of the bridge is to be 85 ft., the towers at high water mark 340×180 ft. The structure will be built entirely of steel. The plans have been quite carefully worked out, and there is no doubt of the entire practicability of the structure. The only question is a financial one. The vast increase of population and business of all kinds and the growth of our country (which will always make New York its metropolis) now demand a bridge fully as adequate as this is proposed to be with its ten tracks. The time will soon come, as at the Detroit River, when the world will no longer be willing to stand on the banks waiting for a passage.

PROPELLER FOR PLEASURE BOATS.

We represent herewith a screw and pedal propeller for pleasure boats.

The person sitting upon the seat (Fig. 1) actuates the pedals, and these give a rotary motion to the main shaft. This motion is transmitted to the screw shaft through the intermedium of a multiplying gearing. The rudder is operated by two wheels, one on each side of the seat.

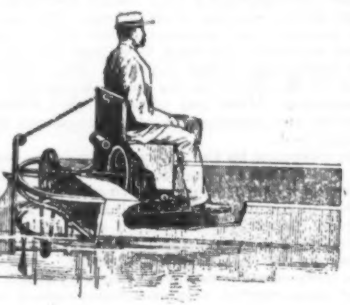


Fig. 1.

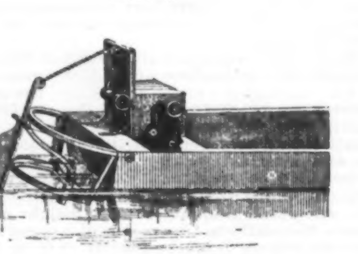


Fig. 2.

PROPELLER FOR PLEASURE BOAT.

Owing to the jointing of the main shaft, and to the arrangement adopted for establishing the apparatus upon the boat, the submerged portion can be lifted by means of a chain that winds around a windlass placed back of the seat (Fig. 2).

This arrangement permits of navigating in places where the water is shallow, and facilitates the keeping of the submerged parts in repair.—*Les Inventions Nouvelles.*

STEAMBOAT WITH DOUBLE HULL AND MULTIPLE PADDLES.

In the floating dock of class 15 of the Exposition there was observed a new type of steamboat arranged for navigating rivers and canals of not very great depth. It had the appearance of a long lighter covered with a rounded roof that extended throughout its entire length.

This boat was exhibited by Mr. Damey, a mechanical engineer, who built and launched it at Bonrepos, near Dole, upon the Rhone and Rhine Canal. The external form of the boat, named the Excursionist, calls to mind a floating house, and was necessitated by the dimensions of the locks and the lowness of the bridges of the canal.

The boat consists of two steel hulls 92 feet in length, upon which there is a deck 98 feet in length by 14 in extreme width. The hulls are 3¼ feet in depth and are divided into 14 water tight compartments. There is a rudder at each extremity.

Forward there is a large saloon, in the center is the boiler and engine, and aft there is a chamber which is reached through two lateral stairways. Near the stern the deck is open in the center to give passage to the propeller, which consists of a metal belt provided with steel paddles and set in motion by two drums 6½ feet in diameter placed between the two hulls.

This system of propeller was invented and patented by Mr. Damey. It constitutes one of the most interesting parts of the whole.

The two drums are situated at a distance of 19 feet from each other, and the space between the paddles is equal to their height. This spacing has been found the most favorable, after a series of experiments. The steam engine that actuates the drums is placed in the center of the boat. It develops a power of 15 horses, and the speed obtained varies from 8 to 10 miles an hour. An ingenious arrangement permits the pilot to regulate the running of the engine without leaving the center of the vessel, where the governing apparatus is. The surface of the submerged transverse sections of the midship frames of the hulls is to the surface of the twelve paddles working all at once in the water as 1 is to 3·8.

The principal advantage of this system, as may be seen, is that it permits of acting upon the water by means of numerous paddles, and consequently with much more efficiency than is done by the ordinary wheels of steamboats. Moreover, it gives the same speed fore and aft.

In answer to an engineer in chief who disputed the utility of having so many paddles in the water, Mr. Damey remarked to him that since a boat provided with six oars makes better headway than the same boat does with two only, the same must be the case with the belt having several paddles acting in the water at the same time.

This boat presents other advantages also as regards navigation in rivers and canals. In fact, its draught is but 14 inches without passengers, and but 18 inches with a full load—70 passengers, baggage, merchandise, etc. Owing to its double hull, there is but little rolling, and its 34 water tight compartments assure of perfect security. Each of the hulls can be separated into three parts. A boat of this kind could therefore be easily carried to the most distant countries. The four rudders render it very easy to steer, even in the abrupt bends of rivers. The speed produced with but 15 horse power could be obtained on a screw propeller only with a greater output of steam.

The Excursionist made a run of less than 270 miles, and passed through 236 locks on its trip from Dole to Paris, and in doing so traversed rivers and canals full of herbage that never obstructed the propeller, whereas a screw would very likely have been stopped.

Several government engineers in chief, who traveled upon the Excursionist, bear witness to the easiness of its running, the absence of rolling, and its very light draught. A slight eddy is produced in front, but nothing of the kind is seen at the stern. In addition the propelling apparatus through its steel paddles destroys the sedges and marine algæ that come in its way.

One valuable advantage to navigation upon canals is due to the fact that this boat, in its running, produces no undulations or waves capable of injuring the banks; and this permits it to run at a greater speed than do steamboats propelled by paddle wheels.

During the Exposition, trials were made of Mr. Damey's boat on the Seine, from Charenton to the Exposition basin, that gave the following results: The engine made regularly 168 revolutions per minute, corresponding to 47·2 at the propeller, which was 6½ feet in diameter or 19⅓ in circumference. The theoretical speed would therefore be 10⅔ miles per hour, provided there was no slipping of the belts on the drums.

The distance from Charenton to the Exposition, which is 7 miles, was made in 45 minutes (deducting a stoppage at Bercy), say 10 miles an hour. We have, therefore, 10⅔ miles—10 miles=⅔ mile for the recoil, that is to say, ten per cent. only.

The inventor asserts that his system can be applied upon the sea as well as upon rivers, and for towing as well as for carrying passengers or merchandise.—*Revue Industrielle.*

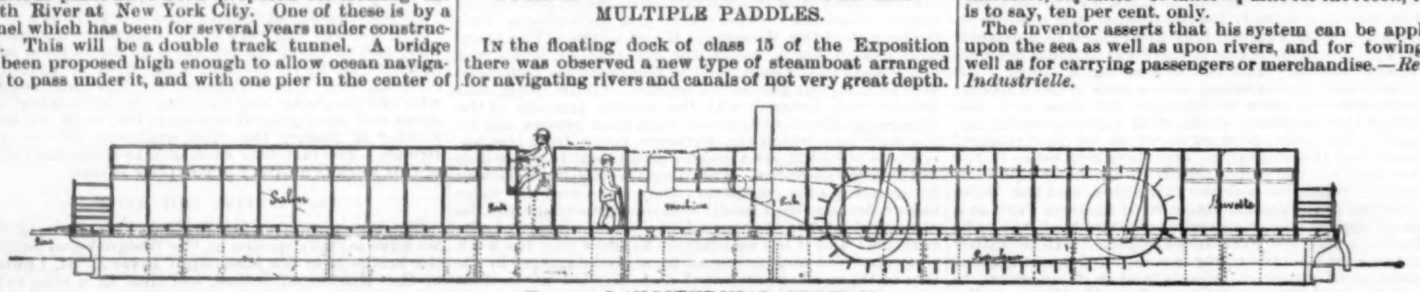


Fig 1.—LONGITUDINAL SECTION.

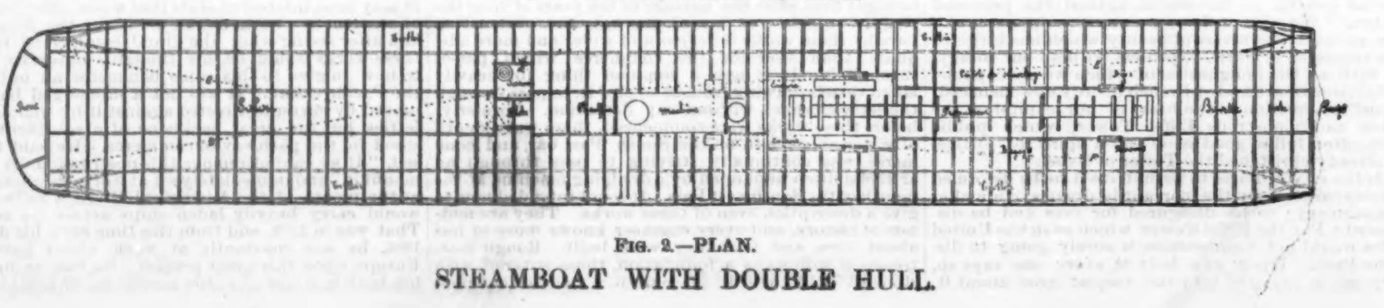


Fig. 2.—PLAN.

STEAMBOAT WITH DOUBLE HULL.

[Continued from SUPPLEMENT, No. 761, page 12158.]

SIBLEY COLLEGE LECTURES.—1889-90.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

IV.—CAR WHEELS.

By ROBERT W. HUNT, of Chicago.

Now I will hand you a book of photographs prepared by Mr. Whitney, and believed by him to demonstrate the value of his chill. The upper series represent a wheel made in the ordinary chill. The lower, a wheel made from the same pattern, out of the same metal, out of the same heat, on the same day, but in the contracting chill. In these pictures you will observe that the chill on the wheel cast in the Whitney chill is not only deeper, but more uniform in its depth.

The gentlemen who are not willing to admit all the claims of the contracting chill maintain that the excellent results shown are produced by other causes.

Then, again, the Ramapo Wheel Co., of New Jersey, have an excellent reputation for their wheels. They use and claim to obtain their good results from a *non-expanding* chill. Their chill is a solid block which has a pipe cast in it, through which cold water is circulated while the wheel is cast.

Mr. Thomas A. Griffin, president of the Griffin Wheel and Foundry Co., of Chicago, some months ago made a series of experiments to demonstrate that he could produce as good results in a Barr contracting chill without as with the use of steam and water; and also that by the length of time in pouring he would in it, as in an ordinary chill, control the depth of chilled metal. He was successful in these attempts. Photographs of this result I present for your observation. Of course Mr. Barr would claim that while this might be possible, nevertheless his chill reduces the liability of bad work.

I fear we will have to withhold our judgment for a little while; in fact, I am reminded of the temperance lecture story, etc.

At the same time I am inclined to think a contracting chill has some merit. It need not perhaps be strictly on either the Whitney or the Barr plan. But I believe the claims of those gentlemen that it guards against bad judgment in pouring are true.

Mr. T. A. Griffin has perfected a system by which he very rapidly and cheaply grinds the face of a cast iron wheel, so as to render it smooth and true, and then balances the wheel by fastening a weight on to the plate of the lightest side. This plan impresses me very favorably.

To give you an idea of the accepted inspection tests, etc., of a cast iron wheel, I quote the Pennsylvania Railroad specifications, with which those of the leading roads practically agree.

PENNSYLVANIA RAILROAD COMPANY'S SPECIFICATIONS FOR THIRTY-THREE INCH CAST IRON WHEELS.

Design.

The design of wheels must be such that they will be in accordance with the measurements shown in the drawing accompanying these specifications, and also such that the wheels made from them shall weigh between 540 and 575 pounds each.

Marks.

All wheels must have cast upon them name of maker, date of casting, and a serial number. Numbers made vacant by rejection or otherwise must not be refilled.

Chills.

All chills must have the same inside profile, as per drawing of wheel accompanying these specifications, their inside diameter measured at throat must be the same, and they must also be truly circular.

Inspection.

All wheels offered for inspection must be measured with the P. R.R. standard tape measure, and must have the shrinkage number stenciled in plain figures on inside plate of wheel. When ready for inspection, wheels should be arranged in rows according to shrinkage, all wheels of the same date being grouped together. All wheels must during inspection receive three or four heavy blows with a twelve pound sledge at as many different points on the inside of the flange between the brackets. No wheel will be accepted the circumference of which is more than 1⅛ inches or less than 1 inch smaller than that of the chill in which it is made. Each wheel must be so nearly circular that when a true metallic ring is placed on the tread and bears somewhere on the cone it shall at no part of the circumference stand more than 3-32 inch away from the tread. Body of the wheel must be smooth, and free from slag and blow holes. Tread and throat of wheel must be smooth, and free from deep and irregular wrinkles, slag, sand wash, and chill cracks, and throat must be practically free from sweat. The wheels tested and broken must show a soft, clean gray iron, free from defects, such as holes containing slag or dirt more than ¼ inch in diameter, or clusters of such holes. The depth of clear white iron must not exceed ⅞ inch at throat and 1 inch at middle of tread. The blending of the white iron with the gray iron behind it must be without any distinct line of demarkation, and the iron must not have a mottled appearance in any part of the wheel at a greater distance than 1⅝ inches from the tread.

Test.

For each 50 wheels which pass inspection and are ready for shipment one representative wheel shall be taken at random by this company's inspector and subjected to the following test: The wheel shall be placed flange downward on an anvil block weighing 1,700 lb. set on rubble masonry 2 feet deep, and having three supports not more than 5 inches wide for the wheel to rest upon; it shall be struck centrally on the hub by a weight of 140 lb. falling from a height of 12 feet. Should this wheel break in two or more pieces after five blows, or less, the 50 wheels represented by it will be rejected. If, however, the wheel stands five blows without breaking in two or more places, the 50 wheels will be accepted and may be shipped, but in all cases shipments will be subject to the return of such wheels as are found upon boring or mounting to be below these specifications in any respect. It shall always be the privilege of the company's inspector to test one representative wheel from each day's foundry work.

(Signed) THEO. N. ELY,
General Superintendent Motive Power.

I have said that with the increased weight and speed of passenger service, safety demanded and caused the use of other than cast iron wheels under it. Perhaps the best known to you by reputation of all steel-tired wheels are the Allen paper wheels, which have been given great prominence by being adopted by the Pullman company for their coaches.

Richard W. Allen made his first set of paper car wheels in 1869. The Pullman company gave him their first order in 1871; and it has constantly been the most prominent built-up wheel.

The Allen wheel has an iron hub and steel tire, the plate of the wheel being composed of straw board paper sheets glued together, and formed into shape under heavy hydraulic pressure, then placed between steel plates which, with the paper filling, are bolted to the hub and tire.

Of the foreign made wheels, Krupp's are the most important. The Canadian roads have adopted them as their standard.

These wheels are formed by a rolled steel tire being bolted to a wrought steel center, onto which it has been shrunk. It is also held by rings and bolts in very much the same manner as the Allen cast iron center wheel.

The Krupp center is made in a very peculiar way. An angle bar of soft steel is rolled, having unequal widths or depths to the legs of the angle at different points in the length of the bar.

These variations are so proportioned that when the bar is coiled on itself, there is a thick hub, tapering off into a thinner plate, which again increases in thickness where it comes against the inside of the tire.

These angle bars are heated and coiled as I have stated, on a mandrel, then subjected to a welding heat; placed in a hydraulic press and squeezed toward the center; the result being a welded coiled soft steel centered wheel, with a higher carboned rolled steel tire. Their service is said to be satisfactory, but the first cost is high. Next

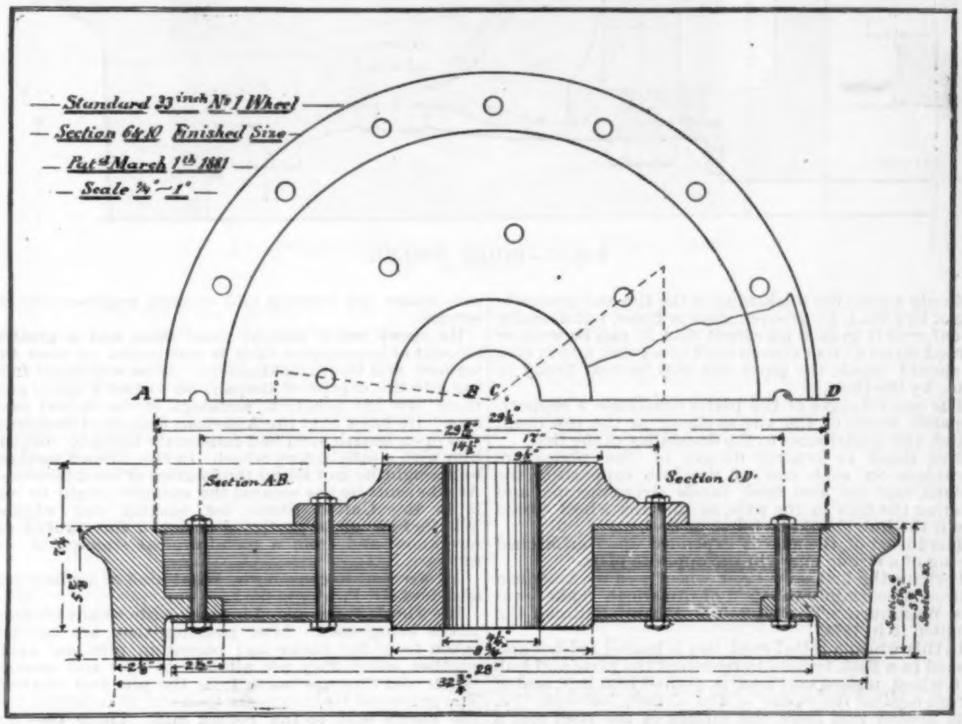


FIG. 5.—ALLEN PAPER CAR WHEEL.

It is claimed for this wheel that the elasticity of the paper reduces the violence of the shocks received, and thus not only tends to lengthen the life of the wheels, but also save wear and tear of rolling stock and roadbed, as well as causing the cars to ride easier.

On the other hand, the wheel is very expensive, and some trouble is experienced from the failure of the bolts, for which various causes are assigned.

The necessary cost of the paper wheel led Mr. Allen to perfect one with a cast iron center into which a steel tire is shrunk. Steel rings are then fitted to the outside circumferences of both faces of the wheel; having projecting ridges fitting into recesses formed in the sides of the tire. The bolts are placed equidistant in the circumference of these rings, and, passing through the cast iron center, hold it and the tire firmly together. The centers are double plates, being cored in casting, uniting into a solid hub. Some are made with spokes, but the double plate is the general pattern.

to the Allen paper wheel, I think the American steel tired wheel best deserving our attention, on account of its prominence in service, if for no other reason, is the Boies. This is made by the Boies Steel Wheel Co., of Scranton, Pa., and is in extensive use. It is claimed for it that its construction is such that a rolled steel tire is joined to a cast hub by two corrugated steel plates of such shapes as to oppose an elastic resistance in every direction from which strains and blows affect it. The tensile strength and elasticity of the metal in these plates permit complete security from their breaking to coincide with the least dead weight in parts not exposed to wear, and the vibrations excited by the constant pounding of the tread of the wheel on the rail are lost in the spring of the curves before they reach the axle, so that this active cause of crystallization of axles is largely removed.

The expansion and contraction of the tire from heat induced by the application of the brakes, and subsequent cooling, is permitted to occur, by the curved

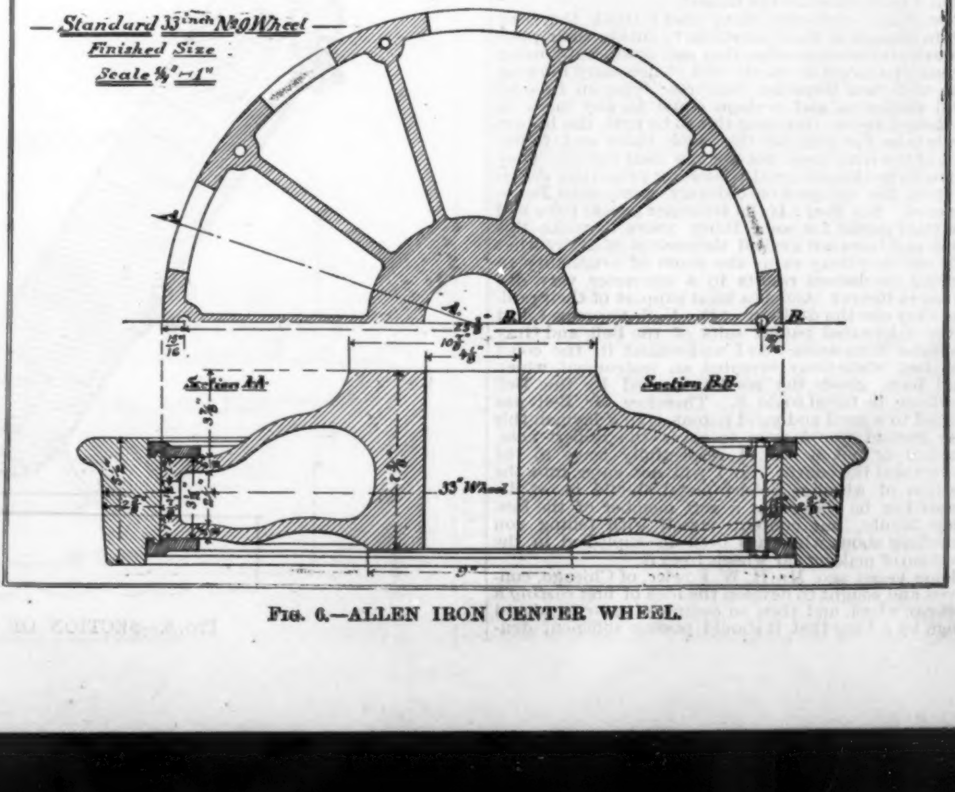


FIG. 6.—ALLEN IRON CENTER WHEEL.

shape of the plates, without causing the bolts to become loose or impairing the strength or durability of the wheel in any respect.

The shape of the plates between the bolts forms a hollow spoke between hub and tire, giving a maximum of strength with a minimum of metal.

The tire is shrunk on and firmly bolted to the plates through a heavy internal flange, which renders it impossible for it to be got off the wheel by accident, and

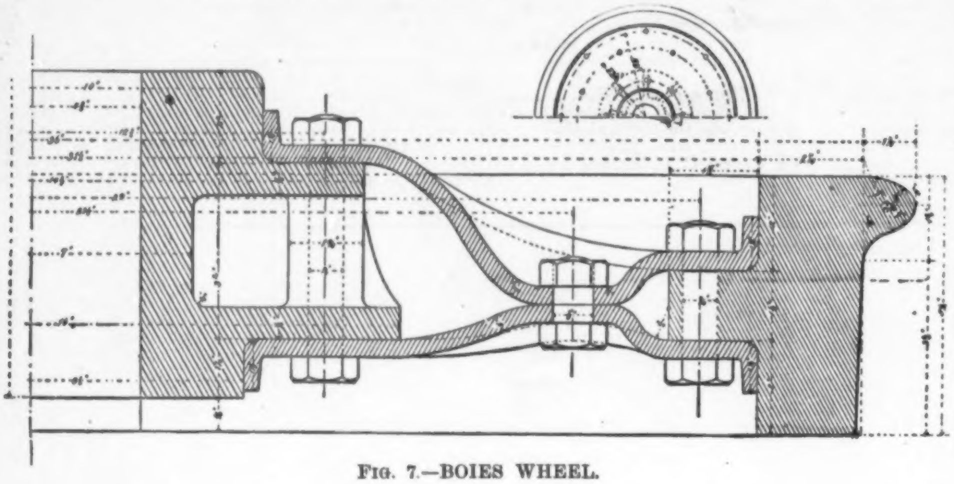


FIG. 7.—BOIES WHEEL.

not only avoids the weakening of the tire and diminishing of tire wear, by grooves, slots or holes, but actually re-enforces it to such an extent that it can be worn or turned down to its extreme limit of service, and in case it should break, the parts will still be held firmly in place by the bolts.

The outer flanges of the plates constitute a supporting arch inside of the tire as elastic as the tire itself, which also contributes to the durability of the tire.

The inner or central flanges of the plates are shrunken on each end of the hub supporting the weight, and are also steel bands strengthening and binding the hub to the axle, so that the wheel would run if the hub should be burst or broken.

The thrust of the axle is expended upon an arched spring of a strong curve in the opposite plate.

Perhaps the first steel-t red wheel used by American railroads—certainly the first of American make—was the Washburn. The Boston & Albany Railroad Co. adopted it in 1870.

In this wheel a rolled steel tire is heated red hot and placed in a flask formed to represent the plate and hub of a wheel, melted cast iron is poured into this, and of course against the inside of the already hot steel tire. The melted iron fuses the surface of the steel and a weld is formed. These wheels are still on the market, but are not as prominent as formerly.

There has been a very decided disposition on the part of the majority of steel authorities to condemn most of the departures from the ordinary Bessemer process. I mean by this, the condemnation of any departure from the usual manner of conducting that process. This was so in relation to the Clapp-Griffith, and has been equally so in treating of the Robert or, as it is more generally known in this country, the Bo ;twalter process.

Even Mr. H. M. Howe in his most admirable work on steel, which has appeared in the columns of the *Engineering and Mining Journal*, has placed himself most decidedly in condemnation of any claims to originality, or even of merit, for either of those processes.

Mr. Howe has given us a valuable work, and one which will be of great assistance to metallurgical engineers. At the same time, while thus warmly indorsing his book, and paying him the highest tribute for his almost unexampled labor and research, I cannot accept all of his conclusions. Mr. Howe's work is that of a pure scientist. Unfortunately for pure science, or rather her priests, we ever once in a while encounter some practical experiences which do not coincide with their deductions.

We will not discuss the Clapp-Griffith process *per se*, but I must consider the Robert.

Now, many engineers claim—and I think they can sustain enough of their assertions to entitle their position to consideration—that they can produce, by using very small charges of metal, and if necessary blowing them with their Bessemer converter lying on its side, metal similar to, and perhaps equal to, any made in the Robert vessel. Granting this to be true, the Robert people take the position that such claim and fulfillment of the same does not weaken their rights. They profess to produce a metal possessing properties different from the accepted or ordinary commercial Bessemer steel. Say they: If the Bessemer people have had it in their power for some thirty years to make this metal, and have not availed themselves of it, by what right can they deny to us the claim of originality in securing the desired results in a converter very dissimilar to theirs? And as a legal support of their position, they cite the decision of the U. S. Supreme Court in the celebrated patent suits of the Bell and Gray telephone companies. As I understand it, the court held that, while Gray invented an instrument which could have given the results secured by the Bell telephone, he failed to do it. Therefore, Mr. Bell was entitled to a good and valid patent. To a layman this same ground would seem to cover the Robert case. Whether or not it will, I respectfully leave to the lawyers and the courts. So I will not enter into the question of whether Robert metal should be so designated or be classed as a soft member of the Bessemer family, but content myself with telling you something about what has been accomplished in the direction of making car wheels from it.

Some years ago, Mr. H. W. Fowler, of Chicago, conceived and sought to develop the idea of first *casting* a steel car wheel, and then so compressing its tread and flange by rolling that it should possess sufficient density to resist the wear of service better than any known wheel.

Following this idea, he developed the mill in which such wheels should be rolled and compressed. While successful in securing a mill which would do this work, he met with an unexpected difficulty in not being able to obtain a steel cast wheel which was sound, that is, free from "blow holes," unless it was so high in either carbon, silicon or manganese that it would not be safe under the varying and onerous requirements of service.

He spent much money, more time, and a greater amount of hopefulness than is vouchsafed to most inventors and their stockholders. As he was about falling into the depths of despair, he visited France, and there saw the practical workings of the Robert process. He knew that the American makers of Bessemer and open hearth steel had constantly failed to furnish him with a satisfactory wheel. In this French method he thought he had found the solution of his difficulties. At all events he has secured the exclusive right to use it in the United States for making car wheels. Whether he can be protected or not in this right, I do not know, and from a metallurgical standpoint, do not care.

All we want to consider is, What kind of a wheel can and does Mr. Fowler make?

His wheels are moulded in sand, without any chilling pieces being used. After pouring they are quickly taken from the flasks and placed in pits, one upon another, where they are allowed to cool and anneal. When cold they are taken from the pits and cleaned. The gates and sinkheads are then cut off in lathes, and the wheels sent to the rolling mill. There they are carefully heated, and while at a comparatively low temperature, placed between the rolls of the mill. The rolling compresses, and thus reduces their diameters. Considering a 33 in. wheel, I find that the flange will be compressed about ⅜ in. and the tread about ⅝ in.

After this rolling they are again placed in annealing pits, and allowed to slowly cool. This annealing is expected to relieve any strains which may have been established by any of the preceding operations.

We have three views of a Robert converter. The metal made in it certainly behaves very different from any other of the same chemical composition which it has been my fortune to observe. Others may have had greater and better opportunities, and witnessed different results. I must be guided by the light given me.

Two analyses of metal in Fowler wheels, which I saw cast, were as follows:

Carbon	0·23 per cent.	0·26 per cent.
Silicon	0·105 "	0·168 "
Phosphorus	0·093 "	0·110 "
Manganese	1·02 "	0·96 "

This metal, when poured into the flasks lay as dead as any cast iron which I have seen handled in foundry practice. The gates and risers were scarcely greater than would have been used for a cast iron wheel.

That you may appreciate this point let me tell you that in the ordinary practice of steel casting, sinkheads and gates for pieces of the same weight as car wheels would amount to 33 per cent. of the total metal poured.

The strength of the metal is illustrated by the following drop breaking tests. The anvil in the following tests was a solid steel ring weighing one ton, and resting upon a foundation, 3 feet 6 inches deep, of solidly rammed scrap and cinder, the wheel under test resting upon its rim, the hub and plate being unsupported.

Size.	Weight.	No. blows.	Wt. Drop.	Fall.	Struck.	Effect.
in.	lb.		lb.	ft.		
33	645	10	155	15	On hub and plate	None.
		20	155	26	" "	"
		1	992	5	"	"
		1	992	11	"	"
		1	99!	15	"	"
		1	992	20	"	"
		1	992	26	"	Crack 4 inches long near rim, but not showing through plate.
		1	992	26	"	Opened crack slightly.
		1	992	26	"	Opened crack through plate.
		1	992	26	"	Enlarg'd crack
		1	992	26	"	Crack extended two-thirds around plate.
		1	992	26	"	Crack extended entirely around plate.
		1	992	26	On rim.	None.
		1	992	26	On hub	Knocked center out, rim entirely sound.
		1	992	26	On rim........	Cracked rim.
		1	992	26	"	Broke rim.
		44				

The analyses given of the steel in Fowler wheels

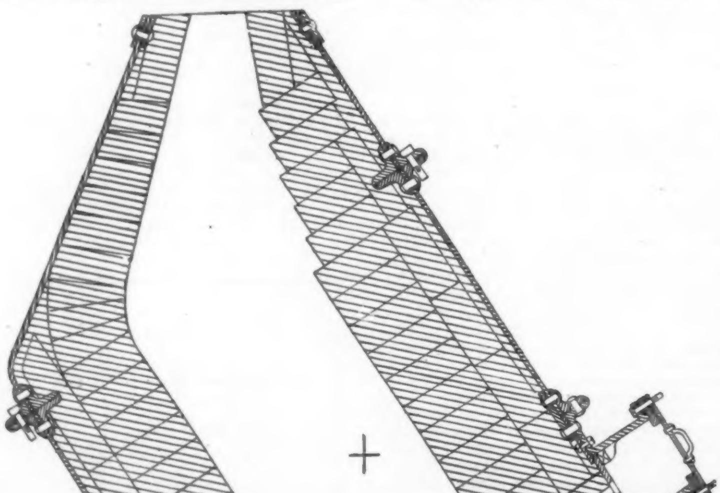


FIG. 8.—SECTION OF ROBERT CONVERTER.

show it to be much softer than has been accepted as proper for steel tires.

In England about 0·40 to 0·45 per cent. carbon is thought right, while for American service steel running from 0·50 to 0·60 is preferred. Of course, if the wheel is cast solid, all parts will analyze the same; hence the question has been raised that, if the tire contains 0·60 carbon, will the plate of the wheel be elastic enough for safety? Mr. Fowler claims it will not. But will his metal, having so low a per cent. of carbon, while safe, be hard enough in tread and flange to give satisfactory wearing results? He thinks he secures this: first, by the density of his castings; and so far as I have been able to investigate, they are free from blow-holes, and very solid; and then as the result of the compression in rolling, he will obtain a physical hardness which will more than compensate for the want of a chemical one; and as his compression is mostly confined to the wearing parts of the wheel, the elastic and safe character of the hub and plate will not be changed.

It is true that steel is very sensitive to the effects of heat and physical treatment. Therefore I think Mr. Fowler's claims are worthy of respect. And fortunately, we shall not have long to speculate in regard to them, as he has sold sample orders to a large number of railroads, and we will soon have results. The New York Central & Hudson River and Manhattan Elevated are among those which are testing the wheels.

There are several other solid steel cast wheels, either on the market or about to be placed there. Perhaps the most prominent one is that of the American Wheel Company, of Boston. This wheel is in service, and its friends claim it is successful. It is cast, and then turned off true in tread and flange. It is not treated in any other way, save annealing, after casting. I have seen some very handsome-looking wheels of this company's make. They are willing to guarantee a service of 150,000 miles, and assume that it will make 300,000 miles under passenger cars. They depend entirely upon their skill in making a sound and safe steel casting. We know how largely steel castings are replacing iron ones, and beyond that usurping the field thought secure to iron and steel forgings. As the American Steel Wheel Co.'s product is fairly on the market, it will be either sustained by its merits or succumb to its weaknesses. I believe a steel cast wheel of some kind is certain to play an important part in railway equipment. Its price will be reduced, and if increased safety is assured, true economy will compel their use.

There is a company at Norristown, Pa., which is said to be ready to erect works in which they propose compressing a steel cast wheel. They have been experimenting for some time I examined what had been accomplished, but was not particularly impressed by any evidence of great success. I suppose Mr. Fowler and they will be apt to furnish pleasant occupation to the patent lawyers.

Mr. B. F. Rittenhouse, of the same place, has devised and patented a plan by which he proposes to take a steel cast blank, which shall more or less closely approach the form of a finished wheel, and in a special mill roll *it out* to the desired form. His scheme is very ingenious. The trouble lies in designing a rolling mill to do the work. But I believe it can be done. If successful Mr. Rittenhouse would take worn wheels, and instead of turning off their tire surface, he would reroll them.

As I have said, I think the mill can be built, but I would not like to guarantee that the first one will be a success.

I have not attempted to name, much less to describe to you, all the wheels which are seeking the favor of railroad officials, and many of them are worthy of your attention. I feel that, as it is, I have taken too long. But as you are so near the end of the time when you have to listen without being at liberty to talk back, I have availed myself pretty freely of my advantage.

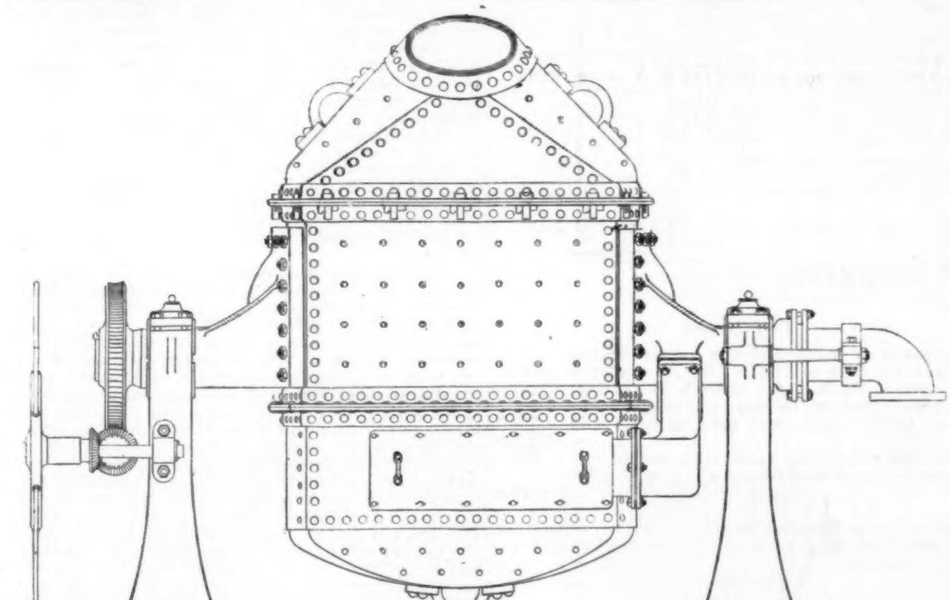


Fig. 9.—ELEVATION OF ROBERT CONVERTER.

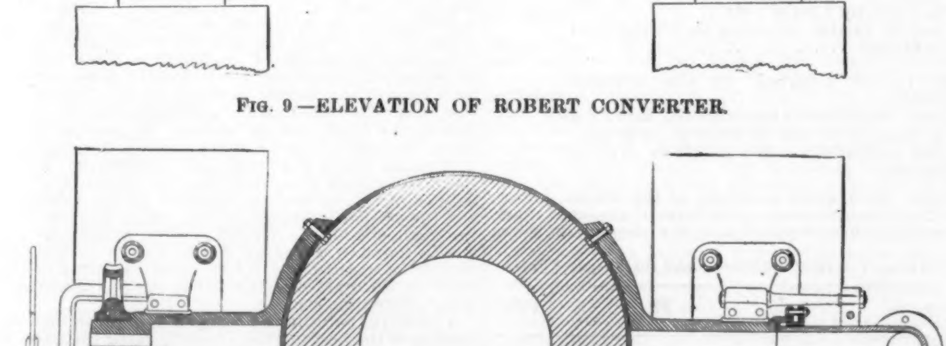


Fig. 10.—SECTION OF ROBERT CONVERTER

APPARATUS FOR MEASURING THE SPEED OF TRAINS.

We illustrate herewith a portable apparatus devised by Engineer Sabouret, of the Orleans Railway, for measuring the speed of trains.

It consists of a copper cylinder, mounted upon a fixed screw, on which, when left to itself, it turns and descends by virtue of its own weight. A spring, C (Fig. 1), holds the cylinder at the top of the screw, and another spring, seen at the top and left of the figure, serves to give it an impulsion in order to effect its descent as soon as the spring, C, is freed. A tuning fork giving the normal *la*, and one of the branches of which is provided with a horse hair, inscribes its vibrations

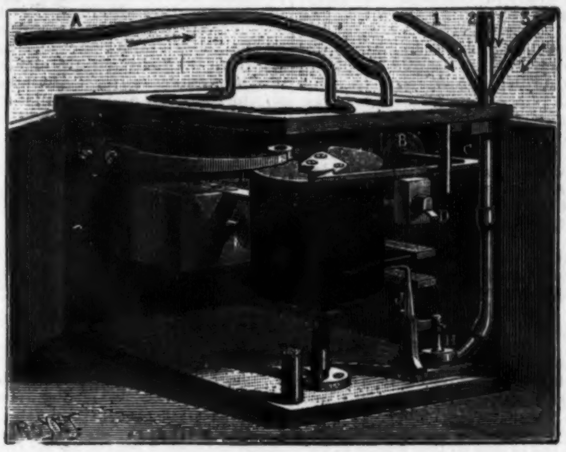


Fig. 1.—APPARATUS FOR MEASURING THE SPEED OF TRAINS.

upon a sheet of smoked paper that covers the cylinder. Above this tuning fork there is a hammer, D, which is freed at the same moment that the cylinder is, and strikes a blow in such a way as to cause the vibrations. Toward the bottom of the cylinder there is a piece, T, which is capable of pivoting at its lower part, and which, when it is slightly inclined, touches the smoked paper and traces a line upon it. This motion is obtained by means of a valve, H, which is raised under the action of the air driven into one of the tubes, 1, 2, 3. The spring, CC, is freed in the same way, by means of a valve, B, to which the air is led by a tube, A.

The tubes, A, 1, 2, 3, are connected with four pedals placed along the rail outside of the track. Each pedal, as shown in Fig. 2, is formed of a small tube of wood containing an aperture into the bottom of which one of the tubes enters. A cork is inserted in each aperture, so that the first wheel of the engine, on passing over it, can drive it in and thus cause a draught of air that suffices to raise the valves. The first pedal communicates through the tube, A, with the bellows, B; the three others communicate, through the tubes, 1, 2, 3 (which afterward unite into one tube in common), with the valve, H.

The first wheel of the engine acts upon the pedal, A, which is placed at a sufficient distance from the others to give the apparatus time to set itself in motion. The wheel next acts in succession upon the pedals, 1, 2, 3, and this has the effect of tracing upon the cylinder three lines indicating the moment in which the operation begins, and the middle and end of the same. The pedals, 1 and 3, are exactly 6 meters apart, and pedal 2 is in the center. We know that the tuning fork gives 435 vibrations per second. By counting the number of vibrations, we can therefore easily deduce the speed of the train per hour:

$$V = \frac{6^m \times 3{,}600^s \times 435^{v'}}{1{,}000 \times n} = \frac{9{,}400}{n}$$

that is to say that if we find that the number of the

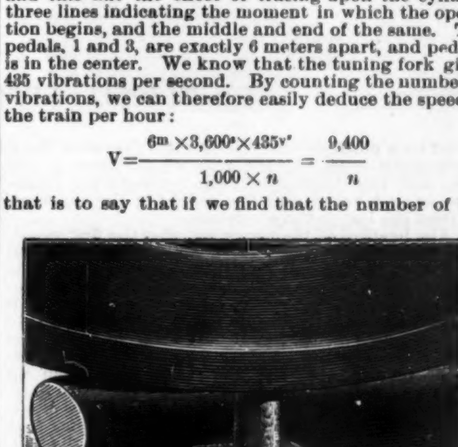


Fig. 2.—PEDAL PLACED ALONG A RAIL.

vibrations n is 94, the train is making 60 miles per hour.

We have said above that pedal 2 is placed midway between the two others. It is designed to verify the operation. In fact, if the latter is well performed, the line traced upon the cylinder by the action of this pedal should divide the number of vibrations comprised between the lines of 1 and 3 into two equal parts. Experiment demonstrates that this verification is obtained in most cases by less than two vibrations, that is to say, the error is less than 2 per cent. when it is a question of a speed of 60 miles per hour—quite a sufficient approximation for the object to be attained.

The apparatus is small enough to be concealed in the ballast. With all its accessories, it fits in a box ten inches in length. It can be put in place in ten minutes at any point of the line, without the engineman being aware of its presence. Supposing that he did perceive

the pedals, it would be too late for him to change the speed of his engine before it was registered by the apparatus.—*La Nature.*

MULTIPLE "EFFET" CONCENTRATORS.

By John G. Hudson, M. Inst. C. E.

Apparatus of this, the most interesting class of all, though known for many years in the sugar industry, have not until recent years come into anything like general use even in that industry, and it is only at the present time that they are being adopted to any extent in the numerous other manufactures requiring concentration. The distinguishing principle of this class of apparatus is the employment of the vapor rising from the liquid under treatment in the first vessel, to cause evaporation in the next vessel; and so on for whatever number of vessels constitute the series. The vapor from the last vessel is almost invariably led to a condenser, in which a high vacuum is maintained by an air pump. This is practically necessary for the attainment of a sufficient working temperature difference when the heating steam is only a few pounds above atmospheric pressure; but where high pressure steam is available, and the liquid not liable to injury by high temperatures, the condenser is not essential. Distillation of water is a case in point. Neglecting certain minor corrections, the result of multiple effet working may be roughly stated as follows:

1. The total evaporation of the whole series of vessels is equal to that which would be performed by one similar vessel taking steam at the same pressure and temperature as the first vessel of the series, and discharging the vapor at the same pressure and temperature as the last vessel. This is due to the whole difference of temperature between the heating steam and the condenser being in this case available in the one vessel in place of being divided, more or less equally, between the different vessels forming the series.

2. Taking the steam required by a single vessel to perform a given amount of evaporation as unity, that needed by a multiple effet to perform the same duty will be unity divided by the number of vessels in the series, and this fraction will also represent the evaporation in each vessel, and the weight of the vapor going from the last to the condenser.

3. Any heating of the liquor entering the first vessel, to bring it up to the evaporating temperature in same, requires the full equivalent of heat from the heating steam, being performed without any advantage due to the multiple effet system, except as regards the heat given up by the liquor on each transfer into the succeeding cooler vessel. At each such transfer the quantity of liquor, and consequently the heat contained, becomes less; and the excess heat given up acts in fewer effets, and therefore to less advantage. The quantity of steam needed to heat the liquor entering the first vessel may approach or even equal that needed for the subsequent evaporation when the temperature of the entering liquor is low, and its volume large compared with the proportion of it to be evaporated in effecting the desired degree of evaporation.

While there is no theoretical limit to the reduction in the consumption of steam due to increasing the number of vessels in the series, the practical limit is soon reached. The gain in economy from each additional vessel is a rapidly falling quantity, and is soon overtaken by the extra cost, complication, and loss by radiation, which are practically constant for each addition, though partially compensated for by the reduced capacity of the condenser and air pump, rendered permissible by the reduction in the volume of vapor discharged from the last vessel. This explains the apparent anomaly that the larger the number of vessels in the series, the smaller the condenser and air pump required. In practice, with heating steam at 5 lb. to 10 lb. pressure as common in sugar works, triple effets are employed in the great majority of cases, and occasionally double and quadruple effets. For the distillation of water by high pressure steam, a larger series would probably be advantageous, and a very high number of effets has been proposed for the purpose, with a view to a maximum fuel economy.

To conduct a full test of so complicated an apparatus as a multiple effet would require considerable preparation and skilled attendance, and the writer is not aware of any such complete and satisfactory test having been made, though plenty of rough practical data are available. In the absence of such a test it is proposed to investigate the theoretical working for one hour of a triple effet apparatus such as indicated in the annexed diagram under the following assumed conditions: (1) Temperatures, pressures, and vacuums as noted on the diagram, these being common averages; (2) 1,000 gallons of sugar juice supplied to first vessel, at the temperature of the liquor already in the vessel, viz., 208 deg., so that no heating is needed. The 1,000 gallons of juice consists of 8,936 lb. water + 1,731 lb. sugar, the corresponding density at standard temperature being 9 deg. Baumé; (3) specific heat of sugar taken as 0·3, so that the 1,731 lb. sugar will have the same capacity for heat as 519·3, say 520 lb. water; (4) no loss by radiation; (5) no loss of pressure due to friction of vapor in pipes; (6) water of condensation discharged at the temperature of the steam from which it was condensed; (7) temperature of the boiling liquor the same as that of the steam rising from it, neglecting the small correction for density; (8) 210 gallons water evaporated in the first vessel; (9) the quantity and densities of the liquor in the vessels the same at finish as at start. Then the following would be the results of the above assumed conditions:

First vessel.

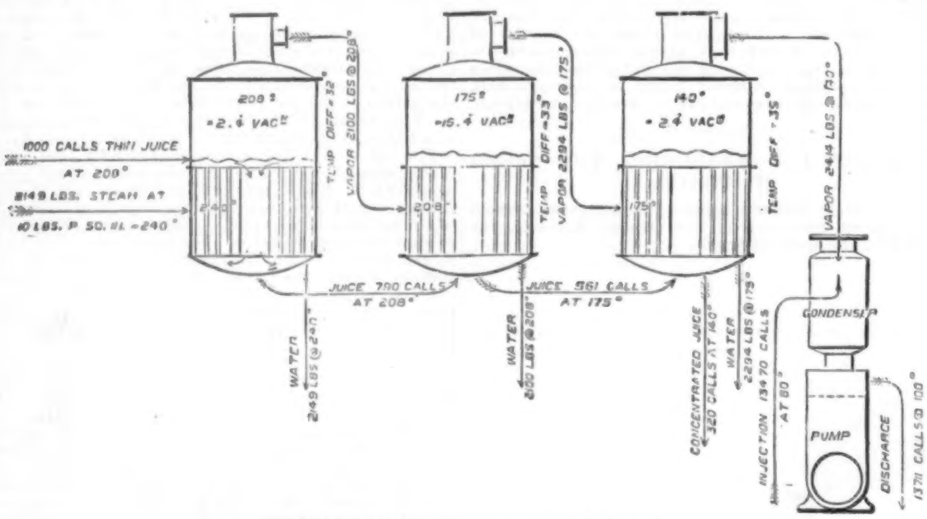
	Units.
To evaporate the 210 gallons water from and at 208 deg. will require 210×10×968 =	2,032,800

The weight of steam at 10 lb. pressure needing to be condensed to provide this heat will be 2,032,800 ÷ 946 = 2,149 lb.

Second vessel.

Receives from the first the balance of the water = 8,936 — 2,100 = 6,836 lb. + all the sugar = 520 lb.; total = 7,356 lb. @ 208 deg. This falling to 175 deg., the temperature of second vessel, will give up 7,356 × 33 deg. .... =	242,748
Receives also 2,100 lb. vapor from first vessel, which on condensing will give up 2,100 × 968 .... =	2,032,800
Heat available for evaporation .... =	2,275,548

and 2,275,548 ÷ 992 = 2,294 lb. water evaporated.



TRIPLE "EFFET" WORKING.

Third vessel.

Receives from the second the balance of the water = 6,836 — 2,294 = 4,542 lb. + all the sugar = 520 lb.; total, 5,062 lb. at 175 deg. This falling to 140 deg., the temperature of third vessel, will give up 5,062 × 35 deg. .... =	177,170
Receives also 2,294 lb. vapor from second vessel, which on condensing will give up 2,294 × 992 .... =	2,275,548
Heat available for evaporation .... =	2,452,718

and 2,452,718 ÷ 1,016 = 2,414 lb. water evaporated.

Condenser.

Receives 2,414 lb. vapor from third vessel, which in condensing to water at 140 deg. will give up 2,414 × 1,016 .... =	2,452,718
and on further reducing to 100 deg. 2,414 × 40 deg. .... =	96,560
Heat to be absorbed by the injection water .... =	2,549,278

and the injection water needed, assuming a range of 80 deg. to 100 deg. = 20 deg., will be 2,549,278 ÷ 20 = 127,464 lb. = 12,746 gallons.

Table No. 5 gives a *resume* of the above figures, omitting the condenser, in the form of a balance sheet, showing the heat received, and the disposal of same.

Table V.—*Heat Balance Sheet for Triple Effet.*

Dr. to	Units.	Cr. by	Units.
Steam entering 1st vessel 2,149 × 1,186	2,548,714	Water drained from 1st vessel, 2,149 × 240 =	515,760
Juice entering 1st vessel, 8,936+520=9,456×208	1,966,848	Water drained from 2d vessel, 2,100 × 208 =	436,800
		Water drained from 3d vessel, 2,294 × 175 =	401,450
		Juice from 3d vessel, 2,648 × 140 =	370,720
		Vapor from 3d vessel, 2,414 × 1,156 =	2,790,584
		Fractions neglected	248
	4,515,562		4,515,562

In the above example the evaporation effected is 2,100 + 2,294 + 2,414 = 6,808 lb. water for 2,149 lb. steam = 3·17 to 1·0, or in practice, allowing for radiation from a well jacketed apparatus, say 3 to 1: 320 gallons of concentrated juice are discharged from third vessel, density at standard temperature = 24·5 deg. B. Had the juice been supplied at atmospheric temperature, say 80 deg., the extra heat needed to raise it to the temperature of the first vessel, 208 deg., would have been (8,936 + 520) × (208 — 80) = 1,210,368 units, requiring 1,210,368 ÷ 946 = 1,280 lb. additional steam, and the ratio of water evaporated to steam used would have been only 1·99 to 1·0, as against 3·17 to 1·0. This shows the need of stating the temperature of the liquor supplied in any record of duty performed. As stated above, the writer has not data of any trustworthy trials of actual apparatus with which to compare the above ideal working, the only data which make any pretensions to completeness being apparently self-condemned by their showing widely varying and irregular values for the amounts of evaporation in the different vessels. As the evaporation performed in, say, the middle pan of a triple effet is the effect of the work done in the previous pan, and the cause of that done in the next, the work of the various vessels cannot vary widely or irregularly. The figures worked out above show that the heat carried over by the liquor tends to make the duty of each vessel rather greater than that of the previous one; on the other hand, leakages and loss of heat by radiation tend in the opposite direction, and it is probable that the evaporation will be nearly the same in each case.

Two types of apparatus are in common use: (1) Vertical pans with brass or gun metal tube plates, brass or copper heating tubes about 2 in. bore by 4 ft. to 5 ft. long, and generally a large central tube to assist circulation by providing for a downward current. The liquid fills the tubes and the steam surrounds them. (2) Horizontal pans, with tubes 12 ft. or so in length, provided with steam chambers projecting from the main shell. Steam in tubes, and liquor surrounding them. Deposit on outer surface of tubes, and these frequently made removable for cleaning. This is generally a cheaper construction than the vertical, apart from the frequent use of iron tubes, and steel or iron tube plates. Some makers, especially the French, graduate the amount of surface in their pans, increasing from the first onward. Presumably this is done to provide for the decreasing efficiency of the surface due to the increasing intensity of the juice. The majority of the other Continental and English makers neglect this refinement, as increasing the cost, without affording any appreciable advantage, and make all the vessels alike, leaving the total working temperature difference to divide itself out between the pans as necessary. Where the temperature of the incoming juice is low, however, it would probably be advantageous to relieve the first vessel of the work of heating it by providing a separate heater for the purpose.

The automatic adjustment of the temperature difference in any vessel of a multiple effet is often overlooked, and attempts are made to adjust it according to the attendant's ideas of what it should be, by admitting a supplementary supply of steam, or opening the connection to the condenser. This is a mistake, as, should a vessel from any cause fail to condense the vapor as fast as it comes forward from the previous one, the vapor will accumulate and the pressure and temperature increase, causing a twofold correction. On the one hand, the rise of temperature reduces the activity of evaporation in, and the supply of vapor from, the preceding vessel; and on the other, increases the temperature difference and condensing power in the sluggish vessel, and these actions continue until a state of equilibrium is reached and each vessel gives off just the amount of vapor that the next vessel can condense.

In the example already worked out, the total temperature difference for the whole apparatus is 240 deg. —140 deg. = 100 deg., and this is assumed to be divided into temperature differences of 32 deg., 33 deg., and 35 deg. in the three pans respectively. This division corresponds very fairly with average working; but considerable variations are sometimes experienced, probably due to some one vessel needing more than its fair share of the difference to compensate for dirty tubes, an accumulation of air in the steam chamber, or some similar accident. Again, if the liquor supply has to be heated through a considerable range, the first vessel will require a proportionately large temperature difference to effect this heating, plus the evaporation. The amount of evaporative duty obtainable from a multiple effet, per unit of heating surface, depends first on the design, and secondly on the handling. As regards the design, the form of the steam chamber should be such as to favor the accumulation of any air in the neighborhood of the discharge orifice, by which it may be removed; the circulation of the liquor over the heating surface must be as active as possible, the vapor pipes must be of sufficient area to avoid any appreciable loss of head between the vessels, and the air pump must be capable of producing a high vacuum. As regards the handling, the attendant must periodically remove any deposit forming on the heating surface, and, when working the apparatus, aim at maintaining the conditions as uniform as possible, as regards the level of liquor in each vessel, the supply of thin liquor to the first vessel and withdrawal of concentrated liquor from the last, the pressure of the steam supply, the vacuum obtained in the condenser, and the efficient drainage of the water and air from the steam chambers. Working in this continuous way will be found to give much better results than the intermittent method, and is facilitated by fitting indices with widely divided sectors to the various liquor and other controlling cocks.

A doubtful point in the design of a multiple effet apparatus is the best method of discharging the water of condensation, and with it any residuary air. As a rule each vessel is dealt with separately; those heated with steam above atmospheric pressure being provided with ordinary traps, while those below atmospheric pressure either discharge into the main condenser or are voided by small air pumps, worked generally off the main air pump engine. Discharging into the condenser is by far the simpler and less expensive arrangement, but requires a careful adjustment of the cocks controlling the flow, in order to prevent an excessive quantity of the heating steam flowing to waste along with the water. To give the attendant a fair chance of making this adjustment, the cock handles should have pointers and graduated sectors, to allow of their being readily set to the positions shown by experience

to give the best results. Perhaps the best plan of all is that occasionally adopted of passing the water from each vessel into the steam chamber of the next, the pipe connections being of progressive area to accommodate the increasing volumes to be passed. The combination flow from the last vessel may go either to the condenser or a small separate pump, the latter plan allowing the distilled water to be kept separate. This is sometimes necessary, to allow this water to be used for boiler feeding or other purposes; though, as a rule, excepting that from the first vessel, it is far from pure, containing ferments which render it unsuited for boilers without some previous corrective treatment. The method of passing the water drained from each vessel through all the successive ones effects a small but perceptible economy of heat, as on each transfer to the succeeding cooler vessel the water parts with heat which does useful work. As the difference between the pressures in two adjacent vessels is but small, the water pipes in place of cocks might have simple diaphragms, pierced with orifices of perhaps twice the area needed to pass at this head the volume of water corresponding with the expected duty. Calculation and experience would easily determine the best area for each case, and the theory of the efflux of gases goes to show that the area of the orifice might probably be made sufficiently liberal to insure a pretty complete voiding of any air, without wasting any considerable proportion of the heating vapor, the volumes of which at the low tensions employed are very great. Further, any heat so carried away would be partially utilized in the succeeding vessels. A refinement in heat economy, frequently practiced by Continental makers, is the heating of the cold juice immediately on its expression by the vapor passing from the last vessel to the condenser. By means of a tubular heater of ample surface a temperature of about 130 deg. is reached, that of the vapor being about 140 deg., more or less, according to the quality of the vacuum.

For multiple effet apparatus of the usual construction, with either vertical or horizontal vessels, the stated duty is generally based by the maker on a total evaporation of from 1·0 to 1·5 gals. per square foot of heating surface in one vessel, but is commonly stated with reference to the gross surface of all the vessels, becoming 0·5 to 0·75 gal. for a double, 0·33 to 0·5 gal. for a triple, and 0·25 to 0·375 gal. for a quadruple effet. This amount of duty should be obtained from any apparatus of fair design, with a very moderate amount of skill on the part of the attendant, and many carefully worked apparatus of ordinary design regularly give results exceeding this by from 50 per cent. to 100 per cent. Continuous night and day working conduces greatly to efficiency, and avoids the loss of time spent in starting and stopping.

Mr. Hagermann, experimenting with a large vertical triple effet, found that an exceptionally large evaporation could be effected by the simple expedient of allowing the liquor level to fall, while working, to about half tube height, the circulation being still maintained by the ebullition with more than common activity—of course, at stopping or starting, the liquor must cover the upper tube plate. This method of using only partially filled tubes, and trusting to the circulation caused by ebullition to bathe their upper parts, is the same as that adopted by Mr. Thornycroft in his water tube boilers. Referring again to the ideal example of triple effet working, an apparatus to do the assumed duty would be liberally provided with 700 square feet of surface in each vessel, and the heat transmission in that case would be 91, 98, and 100 units per degree respectively. In the ordinary types of multiple effet apparatus which have been so far considered, a considerable quantity of liquor, commonly amounting to from 0·33 to 0·5 gal. per square foot of heating surface, is needed to charge the vessels, and this quantity is subjected to the injurious action of the heat for the whole time of working. From the same cause the apparatus cannot be promptly set to work, stopped or changed over from one class of liquor to another. During the past few years, in which the use of multiple effet apparatus has greatly extended, inventors have been busy devising and patenting apparatus which should be free from these objections, and two new designs in particular have attracted attention, viz., the "Yaryan" and the "Lillie" apparatus, both of American origin. In both of these the leading idea is the same, viz., in place of filling the heating tubes with liquor, to pass only a small stream through a considerable length of steam-heated tube, and as far as practicable to cause this liquor to form a thin film over the surface of the tube. The manner of attaining this end is not, however, the same for both.

In the Yaryan the tubes are horizontal, and divided into sections each of as many tubes as required to give about 60 ft. total length, the ends being connected, so as to make each section virtually a tube of this length. Each of these sections receives, as nearly as practicable, its proper proportion of the total feed of liquor, which, propelled principally by the pressure of the vapor rising from it, rapidly performs its 60 ft. journey, and discharges into a chamber common to all the sections, where the juice and vapor separate prior to passing on to the next vessel. The feed of liquor is so adjusted that the degree of concentration desired from each vessel is effected during a single passage through the tubes. In this apparatus the transfer of the partially concentrated liquor from one vessel to the next is in most cases effected by the difference of pressure, as in the ordinary apparatus. Doubtless on account of the definite and rapid flow over the heating surface, this apparatus is claimed to give a high evaporative duty per square foot, reaching from 2·0 to 4·0 gallons per square foot of surface in one pan, or about twice the duty of an apparatus of the ordinary type.

The following results, obtained from a quadruple effet Yaryan apparatus working on esparto liquor in a paper mill, are extracted from particulars published by the Yaryan Company:

Heating surface in each vessel	540 sq. feet
Steam pressure in shell of first vessel	17 lb. = 254°
" " separator of first vessel	2 lb. = 219°
Inches vacuum in separator of second vessel	6 in. = 201°
Inches vacuum in separator of third vessel	14½ in. = 180°
Inches vacuum in separator of fourth vessel	23 in. = 147°
Feed liquor per hour 1020 S. G. at 90 deg. Fah.	=1537½ gallons
Concentrated liquor per hour 1060 S. G. at 138 deg. Fah.	= 176½ "
Water evaporated per hour	1361 "
" " " per square foot heating surface in one vessel	2·52 "
Steam used in heating entering liquor	2119 lb.
" evaporating "	3346 lb.
Evaporation per 1 lb. of total steam	2·5 lb.
" " " evaporating steam	4·07 lb.

The Lillie has vertical tubes of a moderate length, surrounded by the steam. Through each of these the liquor falls in the form of an annular film covering its inner surface, and being returned to the upper end by a pump, traverses the tubes as often as necessary to produce the degree of concentration desired in each vessel, after which it is allowed to pass on to the next one. It seems probable that the evaporative duty of this apparatus per unit of surface will be very similar to that obtained in the Yaryan. Both of these new designs are to a great extent free from the objections already mentioned as belonging to the ordinary types, and although in each case the advantages are accompanied by some loss of simplicity and ease of working, some such improved type bids fair to supersede the older forms. Of course, no advantage as to steam economy can be claimed for any such improved designs, unless they should be found to permit the economical use of a larger number of vessels working in series; as the vessels at present employed utilize all the available heat, less the unavoidable losses by radiation, etc., which are practically equal for all forms. The directions in which improvement may be looked for are reduced weight, cost, and time required for a given duty.—*The Engineer.*

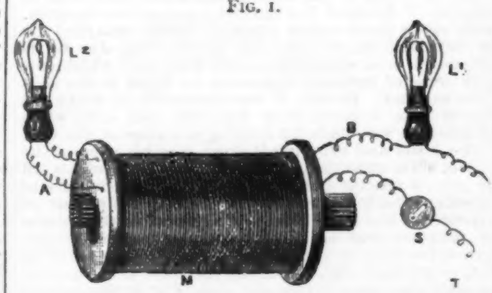
PROFESSOR ELIHU THOMSON'S ELECTRO-MAGNETIC INDUCTION EXPERIMENTS.*

By J. A. FLEMING, M.A., D.Sc., M.I.E.E., Professor of Electrical Engineering in University College, London.

I. IN the Paris exhibition of 1889, and in the United States court, many present will, perhaps, recollect to have seen a collection of electrical apparatus, contributed by Prof. Elihu Thomson as his private exhibit. These pieces of experimental apparatus constituted the appliances for illustrating some highly remarkable and interesting facts in electro-magnetic induction. It is more than probable that very many persons interested in electrical discovery either did not find or did not happen to see in action these instruments, or perhaps had not the opportunity to see them at all. By the kindness of Prof. Elihu Thomson, to whom I am indebted for the loan of the apparatus, it is in my power to repeat some of these experiments before you tonight; and my obligations are likewise especially due to Mr. Ernst Thurnauer, the engineer of the European Thomson-Houston Electric Light Company, for affording me his valuable aid in bringing them before you, and to Mr. Garfield, of the Thomson Electric Welding Company, for assistance in preparing the experiments. A few introductory remarks will be essential, in order that I may carry the whole of my audience with me in subsequent explanations; and these remarks will refer to that which is so very familiar a subject to every electrician, viz., the mutual induction of electric circuits.

Before me lies a very large bobbin or spool, wound over with two insulated copper wires. These wires were wound on the spool together, and for convenience sake we will distinguish them by calling them A and B (Fig. 1). Bear in mind that the wires or circuits are

FIG. 1.



insulated from each other throughout their entire length, but lie closely adjacent on the bobbin. I can at pleasure insert a large bundle of soft iron wires tied up together into the hollow split brass tube which forms the body or the spool. The ends of one wire, say A, are connected to the terminals of a glow lamp, and I can pass or interrupt an electric current which traverses the other circuit, B, and a second glow lamp in series with it. You will note at once what happens when I start or stop the electric current in the circuit, B. The lamp connected to circuit A flashes up momentarily at the instant when the current begins to flow in circuit B, and also when it ceases to flow; but while the current flows steadily in the circuit, B, and illuminates the lamp in series with it, the lamp in series with circuit A is not illuminated at all.

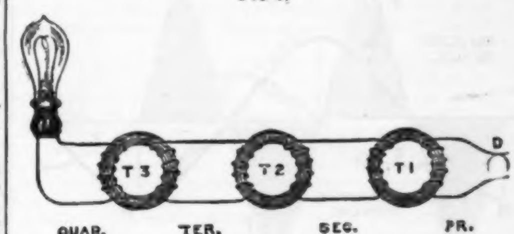
We have here a lecture experiment illustrating the familiar classical discovery of Faraday of the mutual induction of two electric circuits, viz., that the starting or stopping of an electric current in one circuit induces at the instant of commencement or cessation a brief secondary current in another closed adjacent circuit. I shall not take up time by dwelling on the historical details of this fundamental fact. You know them well. If instead of starting and stopping a continuously flowing electric current through the circuit, B, and observing at each "make" or "break" a brief secondary current in circuit A, we supply the circuit, B, with an alternating electric current, one of which the direction is rapidly reversed many times in a second, and connect as before a glow lamp in series with circuit A, we find that this lamp glows continuously while the alternating current flows in circuit B. This also is familiar to us all.

* A paper recently read before the Society of Arts, London.

If in our first experiment we had employed, as a current detector in the secondary circuit, not an incandescent lamp, but some kind of galvanometer capable of indicating the direction of the induced electric current, we could easily have established for ourselves the fact that at the instant when the continuous electric current begins to flow in the circuit, B, it generates an oppositely directed induced secondary current in the circuit, A, which is merely a transient current. At the instant when the continuous current is interrupted in circuit B, it gives rise to a similarly directed transient induced electric current in the circuit, A. The momentary currents in A are called the *inverse* and *direct* secondary currents, induced by the commencement or cessation of the continuous primary current in circuit B. If the primary current is rapidly reversed, as in the case of an alternating current, then the secondary current consists likewise of a rapid succession of currents alternating in direction.

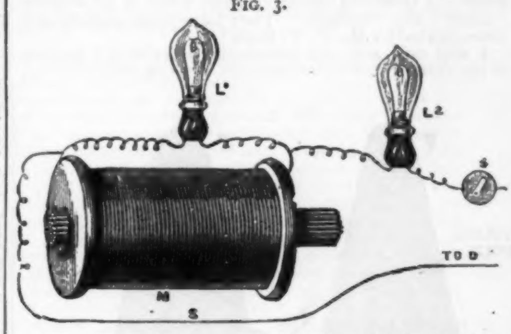
In most of our experiments this evening we shall employ an alternating current, having a "frequency" of 90 per second, that is to say, changed in direction in the circuit 180 times in a second, and provided for us by the kindness of the London Electric Supply Company. If such an alternating current traverses a primary circuit, it induces a secondary alternating current of the same frequency in an adjacent secondary circuit, and this secondary periodic current may be made to induce in another circuit a tertiary current of like frequency, and this, again, a quaternary current, and so on; these successive orders of induced currents being, as it were, the children, grandchildren, and great-grandchildren of the primary parent current to which they owe their birth (Fig. 2.)

FIG. 2.



The same large spool of insulated wire will provide us with the means of illustrating another important fact. I join up the two wires, A and B, into one length, so as to form one continuous bobbin of wire, and connect this great spiral of wire with a couple of glow lamps, one being in series with the wire spiral, and the other being in parallel with it (Fig. 3). On sending

FIG. 3.



a steady current through the system, it divides between the wire spiral, S, and the lamp, L¹, and I adjust the strength of this current so that the lamp, L¹, is barely visibly red hot. On interrupting suddenly this electric current, the lamp, L¹, flashes up for a moment. We recognize that we have here to consider an inertia effect familiar to us as the effect of the "self-induction" in the long coil of wire. Audiences in the room have been so carefully informed on many past occasions by brilliant and capable teachers, that I may spare you a reiteration of elementary facts concerning the self-induction or inductance of conducting circuits, and take it for granted that every one here is intimately acquainted with them, and that you will recall to your recollection that when an electromotive force acts upon any closed electric circuit generating in it an electric current, this self-induction exhibits itself by delaying or retarding the rise of the current strength to its full or its maximum value; and that, similarly, when the electromotive force is withdrawn, it operates to give the current a persistence or to retard the rate of reduction of the current strength. The convenient term "time-constant" of a circuit is employed to denote that time, expressed in fractions of a second or any other unit, which must elapse before a current rises to a certain definite fraction of its full value, when a steady electromotive force acts upon the circuit. I will next beg you to turn a moment's attention to the electro-dynamic actions or forces which are brought into play

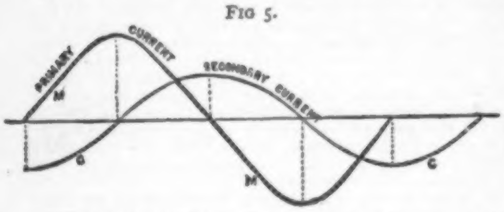
FIG. 4.

when a circuit of any kind is subjected to electro-magnetic induction in a magnetic field.

Consider, for instance, a ring of copper hanging in front of the pole of an electro-magnet (Fig. 4), having the plane of the ring perpendicular to the lines of magnetic force proceeding out from the pole.

Let the magnet be an electromagnet, and let the pole be suddenly made a north or marked pole. Lines of magnetic force are thrust into the aperture of the ring. This magnetic flux, in accordance with a well known law, generates an inductive electromotive force which causes a transient current to flow round the ring in a counter clockwise direction, as looked at *from* the north

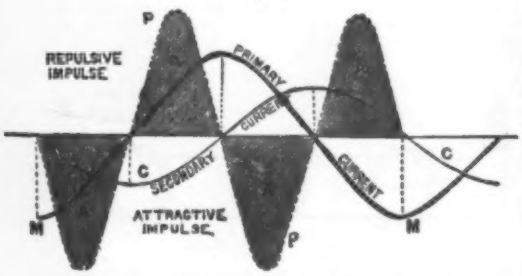
FIG 5.



magnetic pole. The ring becomes virtually a *magnetic shell*, having a north pole facing the north pole of the exciting magnet. By the fundamental laws of action between currents and magnets established by Ampere, the ring experiences a slight repulsive force, due to the electrodynamic action between the current in the ring and the magnetic pole. The generation of the momentary induced current in the ring is accompanied by an electrodynamic impulse tending to thrust it away from the pole.

Suppose, next, that the electromagnet is demagnetized. The ring has generated in it a reverse induced

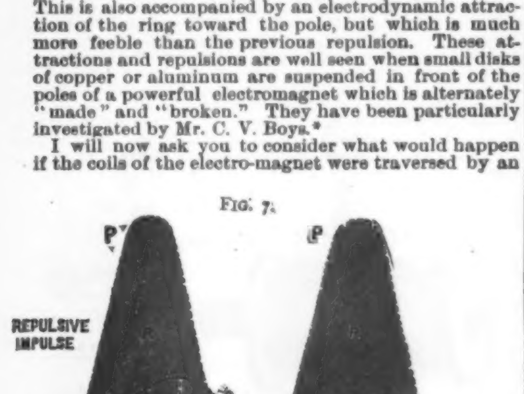
FIG. 6.



current flowing in the same direction as the hands of a clock move when looked at from the magnetic pole. This is also accompanied by an electrodynamic attraction of the ring toward the pole, but which is much more feeble than the previous repulsion. These attractions and repulsions are well seen when small disks of copper or aluminum are suspended in front of the poles of a powerful electromagnet which is alternately "made" and "broken." They have been particularly investigated by Mr. C. V. Boys.*

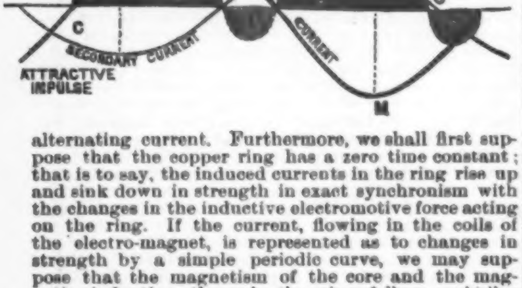
I will now ask you to consider what would happen if the coils of the electro-magnet were traversed by an

FIG. 7.



alternating current. Furthermore, we shall first suppose that the copper ring has a zero time constant; that is to say, the induced currents in the ring rise up and sink down in strength in exact synchronism with the changes in the inductive electromotive force acting on the ring. If the current, flowing in the coils of the electro-magnet, is represented as to changes in strength by a simple periodic curve, we may suppose that the magnetism of the core and the magnetic induction through the ring follow a similar law. It is very easy, then, to show that the induced electromotive force acting in the ring circuit, and

FIG. 8.



hence the current in the ring, follows a similar law of fluctuation, but that the instant of maximum current in the ring coincides with the instant of reversal of magnetism in the electro-magnet. Under these circumstances we can represent the changing strength of the magnetic field in which the ring is immersed by a simple periodic curve, M, and the changes of current strength in the ring circuit by another simple periodic curve, C, shifted backward relatively to the first by a quarter of a wave length (Fig. 5).

By Ampere's law, the force acting on the ring at any instant is proportional to the product of the instantaneous value of the surrounding field and this current strength. If we multiply together the ordinates of these two curves, M and C, and form a third curve, P, whose ordinate at every point is proportional to the product of the ordinates of the other curves (Fig. 6) at those points, we obtain a curve which represents the fluctuation of force at every instant acting upon the ring. This curve, P, is also a wave-like curve, lying symmetrically above and below the horizontal line. The positive and negative areas of this curve included between the curve and the horizontal line represent the impulses or time integrals of the forces which act upon the ring. These impulses are alternately positive and negative. This is equivalent to saying that under the circumstances assumed, the ring gets a series of small pushes and pulls, or repulsions and attractions, which succeed each other at the same rate as the changes of magnetic polarity of the magnet. The series of rapidly alternating and equal impulses would result in leaving the ring apparently unmoved. No real conducting ring can, however, behave in this fashion, because every ring has a sensible "time constant." Let us next see how the above statements will be modified if the ring has such a sensible self-induction that the current induced in the ring lags behind the inducing electromotive force in phase. Repeating the above construction for a force curve, on the assumption that the instant of maximum of the current in the ring occurs later than the instant of reversal of magnetism in the magnet, it is easy to see that the force curve consists now of two very unequal parts. It is not symmetrically situated with respect to the horizontal lines (see Fig. 7). The area of the hummocks (shaded portions) which lie above the datum line, and which represent the repulsive impulses on the ring, are much larger than the area of the hummocks below the datum line, and which represent the attractive impulses acting on the ring. This means to say, that the ring when possessing self-induction experiences on the whole a repulsive force, or a series of repulsive impulses, when immersed in such an alternating magnetic field radiated from a magnetic pole; and this repulsive force will be, within certain limits, more pronounced, other things being equal, the greater the time constant of the circuit. You see clearly, therefore, that a ring or disk of copper in which the induced currents lag behind the inducing electromotive force in phase must experience a repulsive force when this inducing electromotive force is caused by a rapid flux backward and forward of lines of magnetic forces perforating through the ring or disk. The realization of this inference in a striking manner is the first of a series of remarkable experiments on this subject due to Prof. Elihu Thomson. We have on the table an electro-magnet suitable for these experiments, which consists of a core of divided iron, surrounded by a coil in which I can cause to circulate a powerful alternating current of 40 to 50 ampères. Let us, however, begin with an experiment in which we employ a continuous current to energize the core. I give you, in Prof. Elihu Thomson's own words,* an account of this preliminary experiment:

"In 1884, while preparing for the International Electrical Exhibition at Philadelphia, we had occasion to construct a large electromagnet, the cores of which were about 6 in. in diameter and about 20 in. long. They were made of bundles of iron rod about 5-16ths of an inch in diameter. When complete, the magnet was energized by a current from a continuous current dynamo, and it exhibited the usual powerful magnetic effects. It was found also that a disk of sheet copper of about 1-16th of an inch in thickness, and 10 in. in diameter, if dropped flat against a pole of the magnet, would settle down softly upon it, being retarded by the development of currents in the disk, due to its movement in a strong magnetic field, and which currents were of opposite direction to those in the coils of the magnet. In fact, it was impossible to strike the magnet pole a sharp blow with the disk, even when the attempt was made by holding one edge of the disk in the hand and bringing it down forcibly toward the magnet. In attempting to raise the disk quickly off the pole, a similar but opposite action of resistance to movement took place, showing the development of currents in the same direction as those in the coils of the magnet, and which currents, of course, would cause attraction as a result. The experiment could be tried in another way. Holding the sheet of copper by one edge, just over the magnet pole (Fig. 8), the current in the magnet coils was cut off by shunting them. There was felt an attraction of the disk, or a dip toward the pole. The current was then put on by opening the shunting switch, and a repulsive action or lift of the disk was felt. The actions just described are what would be expected in such a case, for when attraction took place currents had been induced in the disk in the same direction as those in the magnet coils beneath it, and when repulsion took place the induced current in the disk was of opposite character or direction to that in the coils. Now let us imagine the current in the magnet coils to be not only cut off, but reversed back and forth. For the reasons just given, we find that the disk is attracted and repelled alternately; for whenever the currents induced in it are of the same direction with those in the inducing or magnet coil, attraction will ensue, and when they are opposite in direction repulsion will be produced. Moreover, the repulsion will be produced when the current in the magnet coil is rising to a maximum in either direction, and attraction will be the result when the current of either direction is falling to zero, since in the former case opposite currents are induced in the disk, in accordance with well-known laws; and in the latter case currents of the same direction will exist in the disk and the magnet coil. The disk might, of course, be replaced by a ring of copper or other good conductor, or by a closed coil of bare or insulated wire, or by a series of disks, rings, or coils superposed, and the results would be the same."

We have already seen that in an alternating field the electrodynamic impulses so experienced by the disk or ring are alternately attractive and impulsive, and that when the circuit possesses a sensible self-induction, the repulsive impulses overpower the attractive ones, and their repetition constitutes a repulsive force. Before adding a few more words of explanation, permit me to show you some of these electrodynamic repulsions produced by an alternating electromagnet. Here is a copper ring, and I lay it upon the top of this electromagnet, having a divided iron core and excited by a powerful alternating current. On energizing the magnet, the ring jumps up in the air (Fig. 9). If a copper plate is hung like

FIG. 9.

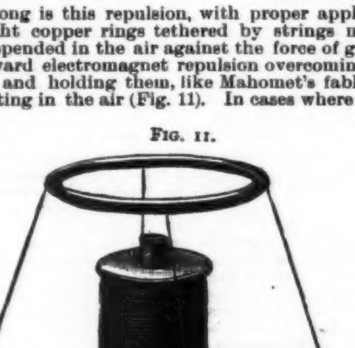
a scale pan from a balanced beam, and placed over the magnetic pole, it gives evidence of being strongly repelled the moment we pass the current through the coils of the magnet (Fig. 10). Instead of employing copper rings or copper plates, we can use closed coils of thick wire, either insulated or not. If, however, our

FIG. 10.

plates or rings have a radial slit made in them, or if our coils of wire are not closed circuit coils, all the effects vanish.

So strong is this repulsion, with proper appliances, that light copper rings tethered by strings may be held suspended in the air against the force of gravity, the upward electromagnet repulsion overcoming their weight, and holding them, like Mahomet's fabled coffin, floating in the air (Fig. 11). In cases where we are

FIG. 11.



dealing only with impulsive effects, aluminum rings or disks give most marked results, because aluminum has the highest conductivity per unit of mass; but in the cases like those just considered, where what is required is the greatest force effect, copper or silver gives a better result than aluminum, because they have the highest conductivity per unit of volume. In Mr. Boys' experiments, if I remember rightly, he found aluminum the best to employ. In these cases of electrodynamic repulsion, the force effect depends essentially upon the lag of the induced current, or it is retardation in phase behind that of the inducing field, and, other things being equal, this is proportional to the conductivity of the circuit. I will pass before your view a series of diagrams intended to represent various cases and modes of production of these repulsive effects, giving you descriptions of them in Prof. Elihu Thomson's own words. He says:

"This preponderating repulsive effect may be utilized or may show its presence in a given direction by producing angular deflection as of a pivoted body, or by producing continuous rotation in a properly organized structure.

"In Fig. 12, C is a coil traversed by alternating currents, B is a copper case or tube surrounding it, but not exactly over its center. The copper tube, B, is fairly massive, and is the seat of heavy induced currents. There is a preponderance of repulsive action tending to force the two conductors apart in an axial line. The part, B, may be replaced by concentric tubes slid one in the other, or by a pile of flat rings, or by a closed coil of coarse or fine wire, insulated or not. If the coil, C, or primary coil, is provided with an iron core, such as a bundle of fine iron wires, the effects are greatly increased in intensity, and the repulsion with a strong primary current may become quite vigorous, many pounds of thrust being producible by apparatus of quite moderate size.

* On a "Magneto-Electric Phenomenon." By C. V. Boys, F.R.S. Proc. Phys. Soc., London, vol. vi., p. 218.

* See the *Electrical World*, May, 1887, p. 258; or the *Electrical Engineer* (American), June, 1887, p. 211: "Novel Phenomena of Alternating Currents," by Elihu Thomson.

"The forms and relations between the two parts, C and B, may be greatly modified, with the general result of a preponderance of repulsive action when the alternating currents circulate.

"Fig. 13 shows the part, B, of an internally tapered or coned form, and C of an externally coned form, wound on an iron wire bundle, I. The action in Fig. 12 may be said to be analogous to that of a plain solenoid with its core, except that repulsion, and not attraction, is produced; while that of Fig. 13 is more

FIG. 12.

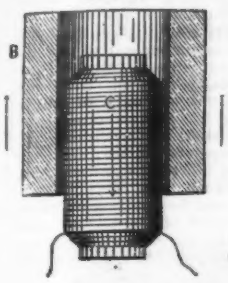
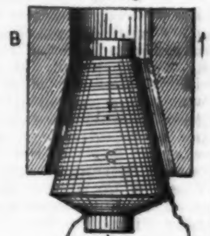


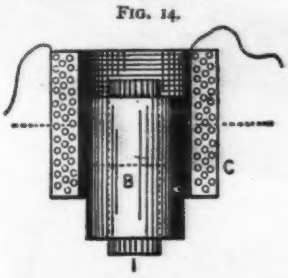
FIG. 13.



like the action of tapered or conically wound solenoids and taper cores. Of course, it is unnecessary that both be tapered. The effect of such shaping is simply to modify the range of action and the amount of repulsive effort existing at different parts of the range.

"In Fig. 14 the arrangement is modified so that the

FIG. 14.

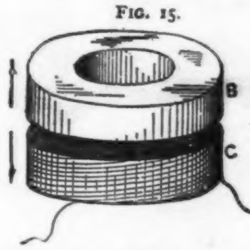


coil, C, is outside, and the closed band or circuit, B, inside and around the core, I. Electro-inductive repulsion is produced as before.

"It will be evident that the repulsive actions will not be mechanically manifested by axial movement or effect, when the electrical middles of the coils or circuits are coincident. In cylindrical coils, in which the current is uniformly distributed through all the parts of the conductor section, what I here term the electrical middle, or the center of gravity of the ampère turns of the coils, will be the plane at right angles to its axis at its middle, that of B and C in Fig. 14 being indicated by a dotted line. To repeat, then, when the centers or center planes of the conductors (Fig. 14) coincide, no indication of electro-inductive repulsion is given, because it is mutually balanced in all directions; but when the coils are displaced, a repulsion is manifested, which reaches a maximum at a position depending on the peculiarities of proportion and distribution of current at any time in the two circuits or conductors.

"In Fig. 15, B represents a copper ring and C an annular coil placed parallel thereto; and an iron core

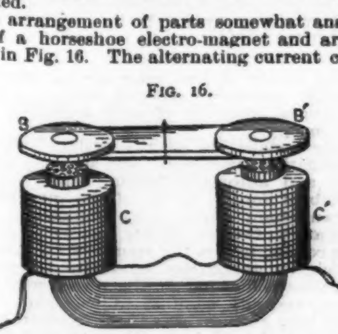
FIG. 15.



or wire bundle, placed in the common axis of the two coils, shows the repulsive action when an alternating current is passed through C. B may be simply a disk or plate of any form, without greatly affecting the nature of the action produced. It may also be composed of a pile of copper washers or a coil of wire, as before indicated.

"An arrangement of parts somewhat analogous to that of a horseshoe electro-magnet and armature is shown in Fig. 16. The alternating current coils, C C',

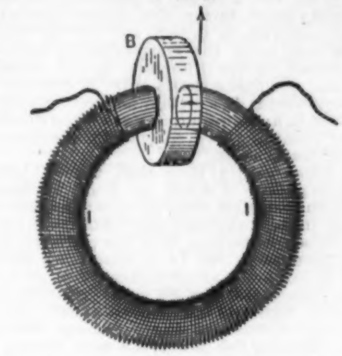
FIG. 16.



are wound upon an iron wire bundle bent into U-form, and opposite its poles is placed a pair of thick copper disks, B B', which are attracted and repelled, but with an excess of repulsion depending on their form, thickness, etc.

"If the iron core takes the form of that shown by II, Fig. 17, such as a cut ring with the coil, C, wound thereon, the insertion of a heavy copper plate, B, into the slot or divided portion of the ring will be opposed by a repulsive effort when alternating currents pass in C. This was the first form of device in which I noticed the phenomenon of repulsive preponderance in question. The tendency is to thrust the plate, B, out of the slat in the ring, excepting only when its center is coincident with the magnetic axis

FIG. 17.



joining the poles of the ring between which B is placed.

"If the axes of the conductors (Fig. 15) are not coincident, but displaced, as in Fig. 18, then, besides a simple repulsion apart, there is a lateral component or tendency, as indicated by the arrows. Akin to this is the experiment illustrated in Fig. 19. Here the conductor, B, is placed with its plane at right angles to

FIG. 18.

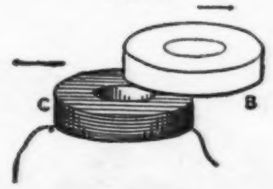
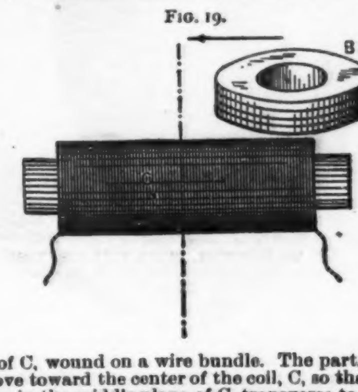


FIG. 19.



that of C, wound on a wire bundle. The part, B, tends to move toward the center of the coil, C, so that its axis will be in the middle plane of C, transverse to the core, as indicated by the dotted line. This leads us at once to another class of actions, *i. e.*, deflective actions.

"When one of the conductors, as B (Fig. 20), is composed of a disk or, better, of a pile of thin copper disks, or of a closed coil of wire, is mounted on an axis, X, transverse to the axis of coil, C, through which coil the alternating current passes, a deflection of B to the position indicated by dotted lines will take place, unless the plane of B is at the start exactly coincident with that of C. If slightly inclined at the start, deflection will be caused as stated. It matters not whether the coil, C, incloses the part, B, or be inclosed by it, or whether the coil, C, be pivoted, and B fixed, or both be pivoted. In Fig. 21 the coil, C, surrounds an iron

FIG. 20.

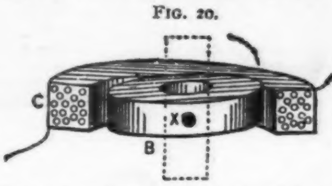
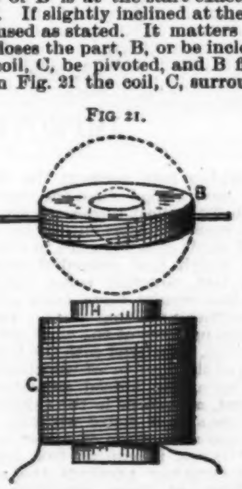


FIG 21.



wire core, and B is pivoted above it, as shown. It is deflected, as before, to the position indicated in dotted lines.*

* This deflection by an alternating current of a copper disk suspended within a coil with its plane inclined to the plane of the coils, I myself noticed independently, in March, 1887, and subsequently described a copper disk galvanoscope for alternating currents, based on this fact (see *The Electrician*, May 6, 1887). I did not, at the time, know how thoroughly Prof. Thomson had explored the phenomena, but the substantial explanation of it had already occurred to me.

"It is important to remark here that, in cases where deflection is to be obtained, as in Figs. 20 and 21, B had best be made of a pile of thin washers or a closed coil of insulated wire, instead of a solid ring. This avoids the lessening of effect which would come from the induction of currents in the ring, B, in other directions than parallel to its circumference."

(*To be continued.*)

THE CHEMISTRY OF GOUT.

AT the last meeting of the London Medical and Chirurgical Society an important contribution to our knowledge of the chemical changes occurring in the tissues of gouty persons was brought before the Society by Sir William Roberts, in the form of a very elaborate paper on the subject.

In bringing forward the subject Sir William Roberts referred to a recent paper of his, in which he had shown that in the physiological state uric acid existed in the blood and urine exclusively as quadrurates, and that when it appeared in any other form this was due to abnormal changes in the quadrurates. In that paper he had traced the changes which the quadrurate underwent in urine—changes leading up to the separation of free uric acid in gravel. In the present paper he proceeded to consider the changes which the quadrurate underwent in the blood—changes leading up to the deposition of free uric acid in gout. These latter changes were intimately connected with the property possessed by the quadrurates of taking up in alkaline solutions an additional atom of base—thereby becoming converted into biurates. A knowledge of this reaction enabled us to present a coherent view of the succession of events which culminated in a gouty paroxysm. Normally, the uric acid, which circulated in the blood as quadrurate, was at once removed unchanged by the kidneys.

But in the gouty state—either from defective kidney action or from some other cause—the quadrurate lingered unduly in the blood; circulating then in a medium rich in sodium carbonate, it was gradually transformed into sodium biurate, which was almost insoluble in blood serum and probably, for this reason, was difficult of removal by the kidneys. Under these new conditions sodium biurate accumulated more and more in the blood, and, when the accumulation reached a certain point, was precipitated in the crystalline form in the joints and elsewhere, thereby determining the occurrence of a fit of the gout. Sir William Roberts said he based this view upon a study of the reactions of blood serum and synovia with uric acid and the urates.

In the case of blood serum these depended essentially on the saline ingredients; the sodium salts exceeded all the other salts put together in the ratio of seven to one, and a solution of 0·5 per cent. of sodium choride and 0·2 per cent. of sodium carbonate was a fairly exact imitation of blood serum so far as concerned its saline ingredients. Experimentally, it was found that such a solution behaved with uric acid and the urates in the same manner as blood serum itself, and in the same manner as a solution composed of all the salines of the serum in their due proportion. The behavior of uric acid and the urates with this standard solution was then studied in detail and the results checked, by comparing them with those obtained with blood serum under similar circumstances. The author found that sodium biurate dissolved in water at 100° F. in the proportion of 1 in 1,100, but that it was almost insoluble in the standard solution and in blood serum, and no addition of potassium, lithium, or magnesium salts—whether alkaline or neutral—made the slightest difference. The solvent power of the standard solution was found to depend exclusively on the sum of sodium salts contained in it, and the degree of alkalescence had not the least influence; the nearer the standard solution approached to pure water, the higher became its power of dissolving sodium biurate, and *vice versa*. The solubility of gouty deposits was tested by suspending gouty articulations, encrusted with uratic deposits, in a large volume of blood serum; the deposits remained unchanged even after immersion for many months. Uric acid itself dissolved freely (as a quadrurate) in the standard solution—and also both in blood serum and synovia—but after an interval of a few hours or a few days it was again precipitated, often somewhat suddenly, in the form of crystalline needles of sodium biurate exactly resembling those found in gouty deposits. The author held that this reaction was analogous to the phenomena of the gouty paroxysm.

In gout, he considered that the blood became increasingly charged with uric acid, until, after a certain period of incubation, sudden precipitation of sodium biurate occurred and the "fit" of gout took place; then followed a process of recovery with restoration of the blood to a purer state. In the experimental process a similar succession of events was observed: solution of uric acid in the medium as quadrurate; gradual conversion of quadrurate into biurate (stage of maturation); deposit of the biurate in the crystalline form (stage of precipitation); restoration of the medium to comparative purity. With regard to the conditions which hastened or retarded the processes which culminated in the precipitation of sodium biurate, the following results were arrived at:

1. Precipitation occurred earlier in synovia than in blood serum.
2. Increased alkalescence of the media favored the stage of solution, but did not retard the stages of maturation and precipitation.
3. The addition of sodium salts hastened maturation and precipitation.
4. The addition of potassium, lithium or magnesium salts had no effect either way—except potassium chloride, which retarded maturation.
5. Maturation was hastened and precipitation occurred earlier at 100° F. than at the temperature of the room.
6. The proportion of uric acid in solution was the circumstance which exercised the most decisive influence on the speed of maturation, and on the time of advent and copiousness of precipitation.

If the proportion of uric acid in solution were 1 in 2,500 or over, there was observed in the middle period of maturation, on the second or third day, a copious critical precipitation; but if the proportions were 1 in 4,000 or under, the precipitation was throughout scanty

and gradual, and postponed to the twelfth or fourteenth day. Dr. George Harley remarked that when Sir Alfred Garrod proved that gout was due to the existence of uric acid in the system, a distinct advance in our knowledge was made. A further advance was made when it was shown that an acute attack of gout was due to the deposition of uric acid in the articular cartilages. Later on, it was shown that the deposits were not due to inflammation of the joints, but that the deposits caused the inflammation around the joints which was known as gout. Sir William Roberts' present paper was a contribution to the chemistry of gout, and Dr. Harley urged that, through chemistry, a new pathology would be founded in which all morbid changes would be proved to be due to chemical action. Dr. Haig observed that Sir William Roberts' paper afforded a chemical explanation which he had long wanted. He had found that alkalies increased the excretion of uric acid, and Sir William Roberts had shown that increased alkalescence favored the state of solution of uric acid. Similarly, acids lessened the amount of uric acid excreted. Sir William Roberts then replied, and remarked that he had confined himself to certain chemical results, and had drawn no conclusion as to the profounder theories of gout. There was something in gout beyond the chemistry of the urates; it was, in essence, a mode of nutrition, associated with an error, which was uric acid. There was a colloidal form of uric acid, as well as the crystalline form, and the action of the two forms also differed. He believed that if an attack were imminent, a patient ought not to take mineral waters containing soda and lime, except very sparingly at first. Dr. Herman Weber had, for many years, warned his patients on this point. Sir William Roberts said he thought it possible that most of the good done at mineral springs was due to the water taken, and not to the salts it contained.—*Medical Record.*

SEWER VENTILATION.

Successful as have been the works of sanitary engineers in most respects, it must be admitted that they have hitherto failed to solve the apparently difficult problem of sewer ventilation, and untold numbers of sewer gratings, constantly emitting offensive and dangerous vapors into the roads of every sewered town and village under the breathing organs of the population, unpleasantly proclaim the fact; it is therefore universally felt that the subject is one demanding the earnest attention of sanitary authorities and their responsible officers.

An interesting experiment in sewer ventilation is now being made by the Portsmouth corporation on one of the main sewers of the borough, under Mr. Murch, the borough engineer. The drainage committee ordered the experiment to be made some months ago, upon the advice of Mr. Boulnois, president of the Association of Municipal and Sanitary Engineers, the late borough engineer of Portsmouth, who, we understand, holds a favorable opinion of the invention; but, owing to his appointment as city engineer of Liverpool, he has been obliged to leave the investigation and reports upon the system, as far as Portsmouth is concerned, to be made by his successor. The section of main sewer chosen for the experiment, and which borders on the Canoe Lake at Southsea, was selected by Mr. Boulnois as being in need of ventilation, and therefore as imposing a severe test upon the invention, the object of which is not only to ventilate the sewers, but, at the same time, to obviate the nuisance and danger to the public health which arise from the foul emanations escaping from the sewer gratings in the roads. Although all sewered towns suffer alike, the importance of the question as affecting the prosperity of a watering place like Southsea cannot be overestimated, especially as a low-level main sewer of this borough passes all along the sea front from Portsmouth to Eastney.

Mr. Archibald Ford, Asso. Mem. Inst. C. E., the consulting engineer to the Fareham Union Rural Sanitary Authority, and Mr. E. G. Wright, ventilating engineer of Portsmouth, are the joint inventors and patentees of the arrangement adopted; the pith of which consists in the provision to the sewer of a special air passage which is disjointed at intervals, and by means of which the air currents are separated from the sewerage flowing along the sewer; the friction of the water on the air current being thus obviated, the air current is found to be under certain control as to its direction, whatever may be the volume or velocity of the sewerage flow; and, further, the powerfully disturbing influence to systematic sewer ventilation which Mr. Santo Crimp's important experiments have shown to be caused by the varying force and direction of the winds is obviated, as the only connections to the outer air are at the uptake and downtake shafts, which are directly connected to the "special air passage," and not to the sewer; the carefully noted records, extending over three months (which we have had the opportunity of examining), conclusively show that the only effect of the wind, whatever the direction, was that as its force increased, the ventilation of the sewer in the required direction was proportionately greater. Referring to our illustrations of the system, Fig. 1 shows a form of the "special air passage" as applicable to large sewers, and Fig. 2 to pipe sewers.

The application to the Portsmouth main sewer, which is 4 feet diameter and about 10 feet below the surface, is similar to Fig. 1; the system, as it is being adopted for the complete sewerage of a new building estate on Portsdown Hill, Cosham, Hants, is with the "patent ventilating pipe," similar to Fig. 2.

In the application to the Portsmouth main sewer the "special air passage" is formed of galvanized steel tubes, averaging 5½ inches diameter and 2 feet 6 inches long, which are suspended from the crown of the sewer, and secured firmly thereto by a simple arrangement speially devised by the patentees.

The air passage is carried along the top of the sewer (just clear of the headway) for a distance of 100 yards, and at the lowest end it is connected to a "downtake shaft" 6 in. in diameter (of the same material as the tubes fitted in an existing manhole), and the out-air connection with this shaft is from the pit under the ordinary road grating, so arranged that all air passing down through the grating must pass into the air passage. At the higher end (which, however, is only slightly higher) the air passage is connected by a 9 in. stoneware pipe to a dwarf brick ventilating shaft arranged to facilitate the taking of records, this shaft standing on land at the side of the road about 40 ft. laterally from the line of sewer; the arrangement is, in fact, similar to that now usually adopted for ventilating house drains, viz., a length of pipe with an uptake and a downtake shaft, but in this system the pipe is disjointed at intervals, as shown, and the air current, instead of relying upon the comparatively feeble motive power caused by the difference in the height of the uptake and downtake shafts only, is provided for by the more powerful and certain action of a small jet of water, fitted in and discharging down the downtake shaft, the jet obtaining its supply under pressure from the adjoining water main.

Carefully taken records show that with a jet consuming only 23 gallons of water an hour (as recorded by meter), a uniform and constant down current of air is maintained in the downtake shaft with striking uniformity, at velocities varying with the pressure in the water main from 330 to 390 ft. a minute (as recorded by Negretti & Zambra's anemometer); this is equivalent to from about 4,000 to 4,500 cubic ft. fresh external air passing regularly and continuously into the air passage, and distributed thereby along the sewer every hour, diluting the sewer air and forcing it in calm weather in its diluted state, at a rate varying from 1,716 to 2,492 cubic ft. per hour, out of the uptake shaft, which, taking into account the depths of the sewage (which have varied when the experiments were taken from 15 to 30 inches), represents approximately—and with little variation—the entire change of the air of the hundred yards of sewer once in every hour.

The records, which had extended over the period since January last, covering some boisterous days, show that the best results have been obtained in the most windy weather, and that on no single occasion has the direction or force of the wind, or other atmospheric conditions, interfered with the perfect and continuous action of the system of ventilation; an automatic ventilating action, indeed, appears to result from the arrangement, as, except in the calmest weather, it is shown that the system acted without resort to the water jet. The consumption of water is, however, so trifling that if its use, in conjunction with the special air passage, so certainly prevents the escape of the sewer ventilation as these experiments show, we imagine that sanitary authorities would gladly avail themselves of such a generally available and cheap means to secure such important results, and especially as the inventors show that the water can be further utilized for flushing the sewers by collecting it in automatic flushing tanks, which tanks, they suggest, can be built to existing sewers, under the dirt pit of the road gratings, without disturbing the road surface.

Regarding the water consumption, the results at Portsmouth show that for each cubic foot of water consumed, 1,246 cubic ft. of air can be introduced into and carried for a considerable di[illegible]ce along the air passage, but in the application to small sewers less water would, we understand, be sufficient; and even possibly more striking and economical results may be obtained. These important experiments point to the conclusion that while the section of sewer to which the system has been applied is thoroughly ventilated by the systematic introduction of f esh external air, and stagnation of the sewer air is thereby prevented, the important point—viz., the prevention of the escape of sewer air at the road surface grating—has been absolutely secured; and they also show that the fresh air can be made to pass regularly and uniformly down road gratings, and the diluted sewer air out of the uptake shaft, which, of iron or other suitable material, similar to those already existing in many towns, can be carried up the front or back of buildings, or in other places adapted for the purpose; such pipes could, of course, have their outlets above the strata or zone of the atmosphere which must be breathed by the populations of our towns and villages.

There is no reason, that we can see, why in any special case provisions might not be made for the escaping diluted sewer air to pass through heat and flame obtained from gas in the upper part of the uptake shaft, but a continual change of the sewer air and the oxidizing power of the outer air on numerous points of outlet, judiciously selected, would, no doubt, render the general adoption of such additional provisions unnecessary.

A complete installation of the system, with the "patent ventilating sewer pipe," and specially arranged manholes and automatic flushing tanks, designed by Mr. Archibald Ford, C.E., one of the inventors, is, we understand, now approaching completion on a building estate at Cosham, Hants, and we hope to be able, in due course, to give the results of the arrangements, which, we gather, are especially designed to secure a continuous flushing of the sewers with fresh air every hour and with water about three times a day, while all the road gratings are to act as downtakes for fresh air; we may also be able to illustrate and explain what, under a general term, we may call the "double tube system of ventilation," as the inventors propose to apply it to drains and soil pipes in connection with the drainage of public institutions and houses.

We may content ourselves now by saying that, so applied, the inventors claim the following advantage to result, viz., the protection of the fresh air inlet from the escape of sewer or drain air, by the prevention of a reversal of air currents in the drains and soil pipes on discharge from the house fittings, and also the prevention of the unsealing of water closet and similar traps.

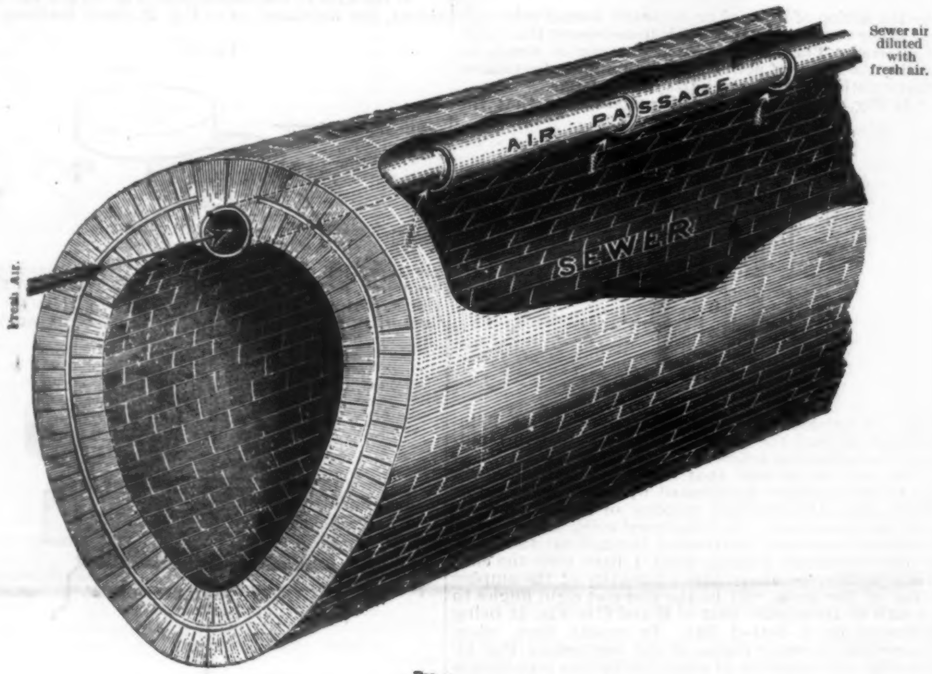


Fig. 1.

Fig. 2.—Elevation.

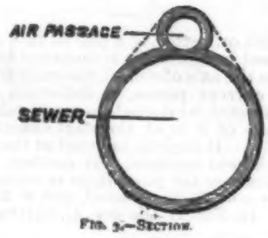


Fig. 3.—Section.

IMPROVED SEWER VENTILATION.

The records we have referred to show that the invention has so f... ood the test of practical experiments at Portsmou.. h and it appears to be based on common sense principles. The inventors clearly take into account, among other points, viz., the well known fact that air will always travel in the easiest direction, and by the special air passage they provide an easy and natural way for it to travel; also that water flowing with velocity in sewers or suddenly discharged down house drains, and wind force acting in certain ways, constantly upset existing sewer and drain ventilating systems, and provide by means of this air passage and its working details protection from such disturbing influences.—*Sanitary Record.*

LOUIS PASTEUR.

On the night of the 20th of June, 1764, toward two o'clock in the morning, two shepherds of the market town of Longueau, near Amiens, were attacked by a she wolf, which bit one of them severely in the face and arm. This shepherd, who was named Antoine Cozette, was thirty-three years of age. He was a stout man and had a good constitution.

M. PASTEUR IN HIS CABINET.

Cozette went the same day to the Amiens hospital, where he was first twice bled; then a palmarin omelet was given him, his wounds were dressed, and on the second day six sols were given him and he was sent home. Twenty days afterward, he complained of pains in his scars and of an inflammation in his stomach, the heat of which increased at the sight of a pot of water or merely when he was spoken to about anything connected with food or drink. The physician who visited him prescribed a compound omelet, and left a package of mercurial ointment for rubbing his leg with, and four grains of turpeth mineral.

The next day Cozette requested his wife to go with him to ask the blessing of the curate. He went out through the garden. As his wife, who followed him in a trembling state, had not the strength to get over the hedge, he took her up and lifted her over. Cozette, in going along, seeing that every one was gazing at him and that the doors and windows were closed at his approach, exclaimed that he was mad, and then lay down alongside of a wall. He was in a paroxysm and foamed at the mouth. His wife, thoroughly terrified, took to her heels, and ran home to barricade the house. After the attack was over, Cozette wished to enter the house, but, finding the door closed against him, went to some of the neighboring houses. But these also were closed against him. The unfortunate fellow then started toward the Camon marsh, the whole village following him with its eye. He was observed to lie down from time to time and to gesticulate with his arms. Then a horrible scene occurred: men armed with sticks and stones went to seize him. One of them, who had provided himself with a rope, made a lasso of it that he succeeded in passing around Cozette's legs; another one threw a cloth over his head; and all, mutually aiding each other, succeeded in tying him firmly and fastening him to a ladder. Then he was placed in a stable. The physician came from Amiens to see him about five o'clock in the afternoon. At this moment, the unfortunate man had all the signs of death upon his face. He could speak but feebly, and as the wound from his last bleeding had opened, he had lost much blood; moreover, he was exhausted by the blows that he had received. He died peacefully toward eleven o'clock at night, with a mass of foam at each side of the mouth as large as one's fist. The next day he was buried with all his clothing and even with the ladder to which he had been tied. By order of the physician, the widow had to burn all the bedding and clothing that she and he had used during this affection.

And now, if the reader likes contrasts, follow us down there to the confines of Vaugirard, toward the newly established institute where the illustrious scientist who discovered the treatment of rabies is daily distributing life to the afflicted who have been subjected to the terrible malady. Let us enter the very sanctuary: Eleven o'clock strikes, and the professor has arrived. There are arranged upon his table ten small glasses covered with filtering paper and in which his confidential assistant has diluted infected spinal marrow in sterilized bouillon. Small syringes are ready. The glasses carry numbers from one to ten and certain dilutions of varying virulence. The door opens, and Mr. Pasteur upon the step of his cabinet, a gray cloth skull cap on his head, and a list in his hand, begins to call the patients.

It is at the hypochondres that the injection is made, and it is therefore necessary to bare the side in order to permit the operator to proceed to the treatment.

Then there occur some little scenes that show the character, education and nationality of the persons bitten. Generally, says Mr. Fredet, the men are ridiculous. I saw one the other day who actually remained five minutes making grimaces before lifting his shirt a little.

The Russians, bitten by a wolf, are calm, placid and respectfully submissive; they are afraid of pain. The Parisian urchin looks as if he were making fun of the operator. He affects bravery. I have seen little Bearnais lads pass, and also solid, well built fellows whose abdominal skin was as brown as their face. And the women? They are from all countries, and they are easily recognized by their manner of proceeding. The Parisian, in order to allow the hypodermic syringe to pass, bares herself generously, the provincial but slightly, and the English woman not at all. It is the latter that gives the most trouble. We must note also the honest peasant who carries a haversack and who politely salutes by throwing his leg backward: "Be you really Mr. Pasteur?" "Yes, I am he, my friend; what do you wish?" "Well, mister, my dog is sick, and I come to ask you if he must be brought here, or if you'd ruther go to see him."

It seems to us that nothing could better proclaim the glory of Pasteur than these two juxtaposed recitals: the horrible disease, the disease without a remedy, the disease that could not be foreseen and that could not be warded off, the disease that in a few hours made a beloved being a sort of reprobate and thing to be dreaded, this disease a man has conquered by force of genius and courage, of patience and labor. We say "courage," and he has it, in fact. Judge of it by the following:

In 1882, Mr. Pasteur was beginning his experiments, and was then collecting the rabic virus from the jaw itself of mad dogs in order to convey it thence, through inoculations, to other dogs. One day a veterinary surgeon telegraphed to him: "Two bull dogs raging mad, come." Mr. Pasteur started, carrying with him six rabbits in a basket. One of the dogs, a huge bull dog, was howling and frothing in his cage. An iron bar was thrust at him, and he jumped at it, and it was with great difficulty that it was wrested from his bloody teeth. One of the rabbits was then brought near the cage, and its drooping ear was passed through the bars; but, despite excitations, the dog betook himself to the back of the cage and refused to bite.

But we must inoculate these rabbits with this froth, said Mr. Pasteur.

Two boys took a cord with a slip noose and threw it at the dog as one would throw a lasso. He was caught and dragged to the side of the cage. He was seized, his jaw was tied, and smothering with rage and with bloodshot eyes, he was laid upon a table and held immovable, while Mr. Pasteur, leaning over at a distance, with a finger on the frothing head, sucked up a few drops of the froth through a tapering tube. It was in that horse doctor's basement, says Mr. Valery Radot,

who accompanied the illustrious scientist on that day, and at the sight of that formidable *tete-a-tete*, that Mr. Pasteur appeared to me the greatest.

It should be understood that we are not attempting a biographical essay on this man, whom all France venerates, and it is also useless to draw his portrait, for every one knows that physiognomy at once paternal and severe, that robust, broad shouldered man who tries, without much success, to give himself a sort of crabbed air that makes him appear more affable still. He was born in the mountains of Jura, of a very honorable and very poor family.

His father, an old soldier decorated upon the field of battle, and obliged upon his return to his fireside to work at the trade of a tanner to gain his bread, often said to him: "Ah! if you could become a professor some day, and a professor at the Arbois College, I should be the happiest man upon earth."

He mentioned Arbois College because he was from Dole; and he did not suspect that fifty-eight years later on, upon the front of the little house in Tanner Street, there would be placed—before his living son, loaded with honor and glory, passing amid a triumphal cortege into the flag adorned city—a plate carrying these words written in letters of gold:

Here Louis Pasteur was born, on the 27th of December, 1822.

On passing this house, on the day of the fete, says Mr. Radot, Mr. Pasteur evoked the image of his father and mother and of those that he called his departed ones, and, from the depths of his memory of childhood, so many recollections of affection, devotion, and paternal sacrifices came to him, that he burst into sobs.—*Le Monde Illustre.*

THE PRODUCTION OF TIN.

IN the very earliest commerce of the world tin held an important position. It entered into the composition of the bronze, which was the universal material for arms and armor long before the Greeks made their famous voyage to Troy. We know that the Phenicians braved the dangers of the Bay of Biscay to obtain it, and doubtless there were other sources less distant than Cornwall from which the people of the ancient world obtained this necessary commodity. Tin is pretty widely distributed in Europe. It was worked in the twelfth century in Bohemia and in the Meissen district of Germany. It is also found in Altenberg, Saxony; in Nantes, Limoges, and Loire Inferieure, France; in Dalicorlia, Sweden; in Spain, and, of course, in Cornwall, Devon, and Somerset, England.

In Southern Asia, and in Siberia, there are extensive deposits of tin ore, while it is also found in Madagascar, Burma, Australia, Peru, and China, Brazil, Bolivia, Tasmania, and Chili. In the United States it is found in the States of Massachusetts, New Hampshire, in the magnetic ores of New York, New Jersey, Missouri; also in the vicinity of King's Mountain, North Carolina; in the gold-bearing formations of Virginia; also in Dakota, Wyoming, Utah, and California.

Many of the sources we have enumerated cannot now be worked profitably, but it is possible that in the early ages of the world they provided the local supplies.

It is estimated that the consumption of tin in the year 1888 amounted to 52,500 tons, distributed as follows:

	Tons.
United States	16,000
Europe	8,000
Other countries	6,000
Used for tin plates	22,500
Total	52,500

The first three items refer to pig tin only, the tin used for tin plate being separately enumerated in the fourth line. It is estimated that another 4,000 tons would be in store and afloat. The sources of the supply are as follows:

	Tons.
Great Britain	9,241
The islands of Banca, Billerton, Sing Kib, and Java, Malacca, and Siak	27,990
Australia	6,559
Mexico, Bolivia, Peru, Chili, Argentine Republic, Tasmania, China, Spain, France, Belgium, Holland, Germany, Russia, and other parts	12,710
Total	56,500

The amount manufactured into tin plate was distributed as follows:

		Tons.
United States,	5,500,000 boxes, weighing	368,300
Great Britain,	1,000,000 " "	67,000
Elsewhere,	1,900,000 " "	127,200
Total	8,400,000	562,500

The records of the Cornish mines have been very carefully kept for a long time, and show clearly the history of the industry. During the 147 years ending in 1889, the average output of the country has been 385,000 tons of ore, yielding 7,045 tons (or 1·83 per cent.) of black tin and 4,620 tons (or 1·2 per cent.) of white tin. The average price of the metal during the period has been £100 8d. per ton. It is estimated that the average cost of mining and reducing one ton of ore to black tin has been (including lord's dues and rates, 1s.) 18s. per ton. The average cost of black tin over the period has been £55 3s. 3d., and the cost of producing it £49 2s. 1d.

During the 147 years the total ore mined was about 56,500,000 tons, and from this there were produced 1,035,503 tons of black tin and 684,623 tons of metal. The highest price of metallic tin was in 1823, when it stood at £184 a ton, and the lowest was in 1843, when it had dropped to £60 a ton. Since 1869 the output has been very steady. In 1874, 230 mines produced 9,942 tons, this being the highest number of mines worked. In 1886 the number had fallen to 72, yet the production, 9,241 tons, had not greatly decreased. In 1888 the output of 81 mines was 9,183 tons.

Within an area four miles long by three miles broad, in the Dolcoath district, there are 51 tin mines, and it is estimated that 25 of these mines have made over £5,000,000 sterling in profits from the sale of black tin. One mill alone made £2,000,000. This mine, the Dolcoath, has an output of 200 tons of ore per day, yielding the high amount of 2·4 per cent. of pig tin, as against 1½ per cent. for the average of fourteen other principal mines. It costs £60 per ton of pig to produce the tin from the ore, and the lord's dues amount to £8.

The fact that Cornish mines are under supervision on account of the lord's dues has caused very accurate records to be made of the output for over a long period:

OUTPUT OF CORNISH MINES—1742 TO 1888.

Dates.	Number of Years.	Tons of Metal Produced.	Average Price, Total Value per Ton. £ s. d.
1742 to 1799	58	156,533	88 7 3
1800 " 1847	48	162,961	99 11 5
1848 " 1857	10	90,180	106 4 2
1858 " 1863	6	42,565	123 5 9
1864 " 1869	6	51,510	100 5 0
1870	1	10,200	127 8 6
1871	1	11,320	137 10 2
1872	1	9,560	152 15 0
1873	1	9,972	133 7 0
1874	1	9,942	108 8 0
1875	1	9,614	90 2 0
1876	1	8,500	79 10 2
1877	1	9,500	73 3 6
1878	1	10,106	65 12 3
1879	1	9,532	72 6 0
1880	1	8,918	91 5 0
1881	1	8,615	97 9 3
1882	1	9,320	106 14 0
1883	1	9,262	97 1 6
1884	1	9,559	84 11 6
1885	1	9,296	89 7 2
1886	1	9,241	101 8 6
1887	1	9,214	113 0 0
1888	1	9,183	117 5 6
		684,623	Average, 100 0 8

The tin ore (black tin) contained in the vein stone (lodes) of twenty-six of the principal tin mines of Cornwall in 1869 amounted to an average of 47 lb. avoirdupois in the ton, or about 2·1 per cent. of black tin, equal to 1·4 per cent. of pig tin per ton of ore mined and reduced. The amount of ore and waste mined in the period covered by the table was about 70,000,000 tons.

Taking two periods, each of sixteen weeks, in 1888 and 1889 respectively, the average cost per ton of mining ore in twenty-five of the tin mines in Cornwall was £1 3s. 2d., the lowest being 16s. 7d., and the highest £1 12s. There were raised 242,200 tons of ore, which yielded 5,466¾ tons of black tin. During the former period (1888) the average price paid for black tin by the smelter was £88 1s. 10d., and in the latter period (1889) £53 6d. Refined English tin sold from £170 a ton in February, 1888.

The following table gives the cost per ton for producing metallic tin from ores assaying from one per cent. upward.

TABLE SHOWING ESTIMATED COST OF PRODUCING METALLIC TIN FROM ORES.

Per Cent. of Metal.	Per Cent. of Black Tin.	Cost per 100 Tons of Ore. Cost of Mining, Lord's Dues, and Transportation. £ s. d.	Cost per 100 Tons of Ore. Cost of Milling and Concentrating. £ s. d.	Cost per 100 Tons of Ore. Total Cost of Production. £ s. d.	Cost per Ton of Smelting Black Tin Containing 66 Per Cent. of Metal. £ s. d.	Total Cost of Production from 100 Tons of Ore. £ s. d.	Cost of Producing Metal per Ton. £ s. d.	Cost of Producing Pig Tin per Ton of Ore Mined. £ s. d.	Profit per Day for 100 Tons of Ore Mined. Metal at £100 a Ton. £ s. d.
1·0	1·5	90 0 0	25 16 0	115 16 8	6 15 0	122 11 8	122 11 8	1 4 6	22 11 8 loss.
1·2	1·83	90 0 0	25 16 0	115 16 8	8 5 0	124 1 8	103 8 7	1 4 10	4 1 8 loss.
1·5	2·27	90 0 0	25 16 0	115 16 8	10 5 0	126 1 8	84 11 1	1 5 2	23 18 4 profit.
2·0	3·0	90 0 0	25 16 0	115 16 8	13 10 0	129 6 8	64 13 4	1 5 10	70 13 4
2·4	3·7	115 16 8	32 1 8	147 18 4	16 13 0	164 11 4	68 8 1	1 12 11	75 8 8
3·0	4·5	115 16 8	32 1 8	147 18 4	20 5 0	168 3 4	56 1 1	1 13 8	131 16 8
4·0	6·0	115 16 8	32 1 8	147 18 4	27 0 0	174 18 4	43 12 3	1 15 0	229 1 8
20·0	30·0	75 0 0	....	....	....	....	....	....	....

This table shows that in Cornwall it does not pay to work a mine in which the ore only assays 1 per cent. of metal or 1½ per cent. of black tin, and that upon a daily output of 100 tons of ore there would be a loss of £22 11s. 8d. per day. Even at 1·2 per cent. of metal there would be a slight loss of £4 1s. 8d. per day. With 1½ per cent. of metal the profit would be £23 18s. 4d. a day, and with 4 per cent. the figure rises to the splendid sum of £229 1s. 8d. With percentages varying from 5 to 20, as found at Temescal, in California, the estimated profits rise to sums which perfectly dazzle the mind. This is exactly what estimated mining profits always do, and occasionally the reality is very good, as, for instance, at the Dolcoath mine, where shares with £9 12s. 6d. paid stand at £100.

Australia produces large amounts of tin. According to Parliamentary returns, there had been imported from that continent, up to the end of 1888, 129,016 tons. The first amount exported was 151 tons in 1872. This rose to 2,472 tons in 1873, and to 5,067 tons in 1874. There was a continuous increase up to 10,964 tons in 1883, from which point there was a steady decline to 6,559 tons in 1888. Tasmania has supplied a large amount of tin, the value of its export between 1872 and 1888 being £4,103,760. The lodes are very rich, and fresh ones have recently been opened out. Hitherto scarcely any deep operations have been attempted. In New South Wales there are considerable placer mines, where the metal is obtained by washing. In the counties of Clark and Gresham, in the district of New England, there are five hundred acres in which deposits of tin and gold are found in alluvial wash.

There have been many attempts to work tin mines in the United States of America, but hitherto they have not met with much success. At Harney Peak, Dakota, great hopes are entertained, and a large number of lodes have been opened out. The Harney Peak tin district presents a circular belt of tin-bearing micaceous slate, formed by a huge cone of bare granite, pushed up into the air 8,000 ft. through layers of slate, carboniferous limestone, and red sandstone. Time has eaten away much of the slate around the peak, and laid bare the tin veins, the *debris* has run into the gulches, and there formed tin placers, known as stream tin. The black tin is disseminated in a granular rock called greisen. There is quartz bearing tin ores, granite veins bearing tin stone, and tin stone in nodular masses. The property is in the hands of a strong syndicate, and is being systematically explored, before commercial operations are commenced. Again, in Wyoming, in 1884, there was the prospect that the production of American tin might become an established industry. Several mines were opened out, and a mill was erected, but the enterprise did not prosper as was anticipated. In Virginia there occurs the Martha Cash tin district, measuring ten miles by four miles. Forty mines have been tested, and these have been found carrying 23 lb. of metal to the ton of ore, or one per cent. The workable ore exists altogether in lumps and veins clearly definable. The ore is cassiterite, or binoxide of tin. A tin deposit also exists at King's Mountain, N. C.; the deposits are long and narrow.

By far the most promising tin district of America is that of Temescal, in San Bernardino County, Cal. It is said to bear a striking resemblance to the geological formation of that part of Cornwall in which the most productive mines are situated. Samples from lodes have been assayed by various experts in England and America, the average result being twenty per cent. of metal to the ton of ore, which is, of course, enormously above the best results obtained in Cornwall.

A strong effort is being made in America to impose import duties upon tin plate, and if this is successful, it will open a new industry to the country, as at present all the tin plate is imported. If the protectionist party should succeed, the value of the local mines will be enhanced, while the tin plate trade of South Wales will be depressed very seriously.—*Engineering.*

THE GLOW OF PHOSPHORUS.*

THE word *phosphorus*, originally applied to any substance, solid or liquid, which had the property of shining in the dark, has gradually lost its generic sense, and is nowadays practically restricted, as a designation, to the wax-like inflammable substance which plays such an important part in the composition of an ordinary lucifer match. Phosphorus, indeed, is one of the most remarkable of the many remarkable substances known to the chemist.

The curious method of its discovery, the universality of its distribution, its intimate connection with the phenomena of animal and vegetable life, it extraordinary physical properties and chemical activity, its abnormal molecular constitution, the Protean ease of its allotropic transformations—all combine to make up a history which abundantly justifies its old appellation of *phosphorus mirabilis*. Godfrey Hankewitz more than 150 years ago wrote: "The phosphorus is a subject that occupies much the thoughts and fancies of some alchymists who work on microcosmical substances, and out of it they promise themselves golden mountains." Certainly no man of his time made more in the way of gold out of the phosphorus than Mr. Hankewitz, for at his little shop in the Strand he enjoyed for many years the monopoly of its sale, guarding his *Arcana* with all the jealousy of a modern manufacturer of the element.

Phosphorus, or, as it was then called, the *noctiluca*, was first seen in this country in 1677. It was shown to Robert Boyle, who had already worked on phosphorescence in general, and who seems to have been specially struck with the remarkable peculiarity of a factitious body which could be made "to shine in the dark without having been before illumined by any lucid substance and without being hot as to sense." In these respects the substance differed from all the *phosphori* hitherto known.

The conditions which determine its glow were the subject of the earliest observations on phosphorus, and Boyle has left us a minute account of his work on the point. In the first place, he noticed that the substance was only luminous in presence of air. He accurately describes the nature of the light, and noticed that the water in which the phosphorus was partially immersed acquired "a strong and penetrant taste, . . . and relished a little like vitriol." On evaporation it would not "shoot into crystals, . . . but coagulated into a substance like a Gelly, or the Whites of Eggs which would be easily melted by heat." On heating this "Gelly" it gave off "flashes of fire and light," and had a "garlick smell." He also found that the *noctiluca* was soluble in certain oils, and he particularly mentions oil of cloves as a convenient means of showing the luminosity, as it is "rendered more acceptable to the standers-by by its grateful smell." "In Oyl of Mace it did not appear luminous nor in Oyl of Aniseeds." Boyle describes a number of experiments showing how small a quantity of the phosphorus is required to produce a luminous effect. "A grain of the *noctiluca* dissolved in Alkohol of Wine and shaken in Water; it rendered 400,000 times its weight luminous throughout. And at another Tryal I found that it impregnated 500,000 times its weight; which was more than one part of Cochineel could communicate its color to." "And

* Lecture delivered on Friday evening, March 14, at the Royal Institution, by Prof. Thorpe, F.R.S.

one thing further observable was that when it had been a long time exposed to the air it emitted strong and odorous Exhalations distinct from the visible Fumes." The strong and odorous exhalations we now know to be ozone.

The earlier volumes of the Philosophical Transactions contain several papers on the luminosity of phosphorus, and one by Dr. Frederic Slare is noteworthy as giving one of the earliest if not actually the earliest account of what is one of the most paradoxical phenomena connected with the luminosity of phosphorus, namely, its increase on rarefying the air. "It being now generally agreed that the fire and flame (of phosphorus) have their pabulum out of the air, I was willing to try this matter *in vacuo*.

"To effect this, I placed a considerable lump of this matter (phosphorus) under a glass which I fixed to an engine for exhausting the air; then presently working the engine, I found it grow lighter (*i. e.*, more luminous), though a charcoal that was well kindled would be quite extinguished at the first exhaustion; and upon the third or fourth draught, which very well exhausted the glass, it much increased its light, and continued so to shine with its increased light for a long time; on readmitting the air, it returns again to its former dullness." This observation was repeated and its result confirmed by Hawksbee in this country and by Homberg in France, and seems subsequently to have led Berzelius, and after him Marchand, to the conclusion that the luminosity of phosphorus was altogether independent of the air (*i. e.*, the oxygen), but was solely due to the volatility of the body.

Many facts, however, combine to show that the air (oxygen) is necessary to the phenomenon. Lampadius found that phosphorus would not glow in the Torricellian vacuum; and Lavoisier, in 1777, showed that it would not inflame under the same conditions; and the subsequent experiments of Schrotter, Meissner, and Muller are decisive on the point that the glow is the concomitant of a chemical process dependent upon the presence of oxygen. It is, however, remarkable that phosphorus will not glow in oxygen at the ordinary atmospheric pressure and temperature, but that if the oxygen be rarefied the glow at once begins, but ceases again immediately the oxygen is compressed. Indeed, phosphorus will not glow in compressed air, and the flame of feebly burning phosphorus may be extinguished by suddenly increasing the pressure of the gas. Phosphorus, however, can be made to glow in oxygen at the ordinary pressure or in compressed air if the gases be gently warmed.

In the case of oxygen the glow begins at 25° and becomes very bright at 36°. In compressed air the temperature at which the glow is initiated depends upon the tension. If the oxygen be absolutely deprived of moisture, the phosphorus refuses to glow under any conditions. This fact, strange as it may seem, is not without analogy; the presence of traces of moisture appears to be necessary for the initiation or continuance of chemical combination in a number of instances.

It was observed by Boyle that a minute quantity of the vapor of a number of essential oils extinguished the glow of phosphorus. The late Prof. Graham confirmed and extended these observations; he showed that relatively small quantities of olefiant gas and of the vapors of ether, naphtha, and oil of turpentine entirely prevented the glow; and subsequent observers have found that many essential oils, such as those of peppermint and lemon and the vapors of camphor and asafœtida, even when present in very small quantity, stop the absorption of oxygen and the slow combustion of phosphorus in air.

It has been established that whenever phosphorus glows in air or in rarefied oxygen, ozone and hydrogen peroxide are formed, but it is not definitely known whether the formation of these substances is the cause or the effect of the chemical process of which the glow is the visible sign. That there is some intimate connection between the luminosity of the phosphorus and the production of these bodies is highly probable. Schonbein, as far back as 1848, sought to demonstrate that the glow depends on the presence of ozone. It is certainly true that many of the substances, such as the essential oils, which prevent the glow of phosphorus also destroy ozone. At a low temperature, phosphorus produces no ozone in contact with air, neither does it glow. It has been found, in fact, that with air, ozone is produced in largest quantity at 25°, at which temperature phosphorus glows brightly. On the assumption that the oxidation of the phosphorus consists in the immediate formation of the highest oxide, the production of the ozone and the hydrogen peroxide has been represented by the following equations:

$$P_2 + 3O_2 = P_2O_5 + O.$$
$$O + O_2 = O_3.$$
$$O + H_2O = H_2O_2.$$

Both these reactions may, of course, go on simultaneously; ozone and hydrogen peroxide are not mutually incompatible; the synthesis of hydrogen peroxide by the direct oxidation of water seems to occur in a number of processes. But such symbolic expressions can at most be only very partial representations of what actually occurs. It is highly probable that the combination which gives rise to the glow only occurs between the *vapor* of phosphorus and the oxygen. Phosphorus is sensibly volatile at ordinary temperatures, and by rarefying the atmosphere in which it is placed its volatilization is increased, which serves to account for the increased glow when the pressure of the gas is diminished.

When phosphorus is placed in an atmosphere of hydrogen, nitrogen, or carbonic acid, these gases, when brought into contact with oxygen, become luminous from the oxidation of the vapor of phosphorus diffused through them. The rapidity of volatilization varies with the particular gas; it is greatest in the case of hydrogen and least in that of carbonic acid. Indeed, a stream of hydrogen gas at ordinary temperatures carries away comparatively large quantities of phosphorus, which may be collected by appropriate solvents. No ozone and no glow is produced in oxygen gas at ordinary temperatures and pressures, but on warming the oxygen, both the ozone and the glow are formed.

On passing ozone into oxygen at temperatures at which phosphorus refuses to glow, the phosphorus at once becomes luminous, oxygen is absorbed, and the characteristic cloud of oxide is produced, and the effect continues so long as the supply of ozone is maintained. A drop of ether at once extinguishes the glow. The ether is in all probability converted into vinyl alcohol with simultaneous formation of hydrogen peroxide by the reaction indicated by Poleck and Thummel:

$$\left.\begin{matrix} CH_2CH_3 \\ CH_2CH_3 \end{matrix}\right> O + O_3 = \begin{matrix} CH_2CHOH \\ CH_2CHOH \end{matrix} + \left.\begin{matrix} HO \\ HO \end{matrix}\right\}$$

A. W. Wright has shown that formic, acetic, and oxalic acids are also formed by the action of ozonized oxygen on ether.

Phosphorus combines with oxygen in several proportions, and the study of the mode of formation and properties of these oxides is calculated to throw light upon the nature of the chemical process which attends the glow of phosphorus. Certain of these oxides have recently been the subject of a considerable amount of study in the chemical laboratories of the Normal School of Science.

When phosphorus is slowly burned in air, there is produced a considerable quantity of a volatile substance, having a characteristic garlic-like smell, which solidifies, when cooled, in beautiful arborescent masses of white crystals. It melts at about 23°, and boils at 173°. In a sealed tube kept in the dark it may be preserved unchanged, but on exposure to light, and especially to bright sunshine, it rapidly becomes deep red. It slowly absorbs oxygen at the ordinary temperature and pressure, but from the mode in which the solid production of the reaction (P_2O_5) is deposited, it is evident that the union only takes place between the *vapor* of the oxide and the oxygen gas. Under diminished pressure the act of combination is attended with a glow which increases in brilliancy if ozone be present.

On compressing the oxygen the glow ceases. No ozone is formed during the act of oxidation. The degree of rarefaction needed to initiate the glow depends upon the temperature of the oxide—the warmer the oxide, the less is the diminution of pressure required. By gradually warming the oxide, the luminosity steadily increases both in area and intensity, until at a certain temperature the mass ignites. The change from glow to actual flame is perfectly regular and gradual, and is unattended with any sudden increase in brilliancy. In this respect the process of oxidation is analogous to the slow and barely visible burning of fire damp which is sometimes seen to occur in the Davy lamp, or to the slow combustion of ether and other vapors, which has been specially studied by Dr. Perkin. Other instances of what may be called *degraded combustion* are known to chemists. Thrown into warm oxygen, the substance bursts into flame at once and burns brilliantly, and it also takes fire in contact with chlorine.

Alcohol also ignites it, and when it is warmed with a solution of potash or with water it evolves spontaneously inflammable phosphureted hydrogen. In contact with cold water it suffers only a very gradual change, and many days may elapse before even a comparatively small quantity is dissolved. This substance has long been known; it was discovered, in fact, by the French chemist Sage, but its true nature has only now been determined. Its chemical formula is found to be P_4O_6; hence its composition is similar to that of its chemical analogue, arsenious oxide.

The study of the properties of this remarkable substance enables us to gain a clearer insight into the nature of the chemical process attending the glow of phosphorus. When phosphorus is placed in oxygen, or in an atmosphere containing oxygen, under such conditions that it volatilizes, the phosphorus oxidizes, partly into phosphoric oxide and partly into phosphorous oxide. Ozone is formed, possibly by the reaction already indicated, and this reacts upon the residual phosphorous vapor and the phosphorous oxide, with the production of the luminous effect to which the element owes its name. The glow itself is nothing but a slowly-burning flame having an extremely low temperature, caused by the chemical union of oxygen with the vapors of phosphorus and phosphorous oxide. By suitable means this glow can be gradually augmented, until it passes by regular gradation into the active, vigorous combustion which we ordinarily associate with flame. Many substances, in fact, may be caused to phosphoresce in a similar way. Arsenic, when gently heated, glows in oxygen, and sulphur may also be observed to become luminous in that gas at a temperature of about 200°.

THE COMPOSITION OF BOILER SCALE.*

By THOS. B. STILLMAN.

THE results of an analysis of boiler scale usually represent the lime and magnesia as carbonates with a portion of the former as sulphate—on the general principle that the scale made continues to exist in the form in which it was precipitated. In those portions of the boiler where the direct heat does not come in contact with it, the scale remains unchanged after formation, but the conditions are altered where the scale is subjected to intense heat. In the latter case, while the deposition of the scale-forming material at first occurs as carbonate and sulphate, the gradual heating expels some of the carbonic acid, and the oxides of calcium and magnesium are formed.

That portion of the scale nearest the iron and to the heat loses more of its carbonic acid, and becomes caustic so long as the fire continues.

As soon, however, as the fires are drawn, the oxides of calcium and magnesium become hydrated by absorption of water.

If now a sample of the scale were taken for analysis, the water of hydration becomes an important factor in the analysis:

A sample of scale from some boilers at Birmingham, Ala., recently submitted to me for analysis, gave the following result:

Silica and clay	11·70	per cent.
Fe_2O_3, Al_2O_3	2·81	"
CaO	11·62	"
MgO	41·32	"
CO_2	6·94	"
SO_3	0·96	"
H_2O (of hydration)	21·78	"
H_2O (moisture at 212° F.)	0·69	"
Undetermined	0·20	"
Total	100·00	per cent.

* *Journal of Analytical Chemistry*, vol. iv., Part 1, January, 1890.

An examination of this analysis shows an unusually small amount of carbonic and sulphuric acid, a large amount of water and of magnesia.

The great excess of the latter over the lime indicates that the water from which the scale was formed is a magnesia water, but its presence in this amount does not in any way alter the conditions of the problem.

With less than 1 per cent. of sulphuric acid and less than 7 per cent. of carbonic acid, the oxides of calcium and magnesium could not exist in their entirety as carbonates or sulphates, for, combining the above acids to form carbonates and sulphates, the result indicated over 20 per cent. lacking in the 100 parts.

The determinations of the carbonic and sulphuric acids were in duplicate and in every way satisfactory, while no organic matter of any amount was indicated in the analysis.

The large percentage of the oxides of calcium and magnesium left after combination with the acids suggested water of hydration.

A sample of the scale (dried at 100° C.) was transferred to a platinum crucible and heated over the blast lamp to a certain weight. The loss of weight was over 28 per cent., and, of course, included the carbonic, but not the sulphuric acid.

To check this result, a sample of the dried scale was ignited in a combustion tube and the H_2O collected in a weighed chloride of calcium tube. The result was 21·78 per cent. of water of hydration.

This satisfied the conditions existing, and the combinations gave as follows:

Silica and clay	11·70	per cent.
Fe_2O_3, Al_2O_3	2·81	"
$CaSO_4$	1·69	"
$CaCO_3$	5·45	"
$MgCO_3$	7·36	"
$Ca(OH)_2$	13·70	"
$Mg(OH)_2$	56·37	"
H_2O (moisture at 212° F.)	0·69	"
Undetermined	0·20	"
Total	99·97	per cent.

A section of the scale was subjected to examination, layer by layer, and the following results confirm the above.

That portion of the scale next the iron and nearest the fire contained but traces of CO_2, and was principally the hydrated oxides. The middle portion of the scale was a mixture of CO_2 and the hydrated oxides, while the upper portion of the scale contained carbonates but no hydrated oxides. In other words, the composition of the scale will depend, in a great measure, upon what portion of the boiler the deposit is made. That deposited on the iron or shell not in contact with the flame or not subjected to extreme heat will remain as deposited—as carbonates and sulphates; while that scale deposited upon the iron, subject to the flame or heat sufficient to drive out any carbonic acid from the scale, will vary in the amounts of CO_2 and water of hydration as indicated.

Scale formed in which the lime all exists as calcium sulphate and in which no magnesium carbonate is present will be subject to but little variation.

AUTOGRAPHISM.

THE subjects whose history and photographs were presented by Dr. Mesnet to the Academy of Medicine the other day may congratulate themselves upon living in the year of grace 1890. Three centuries ago they would certainly have been included among those unfortunates whom ignorance and a belief in the supernatural classed among those possessed of a demon. The author of this interesting communication himself would have done well at that epoch to keep quiet. He also would have been accused of being a sorcerer, and the sentence of parliaments for these so-called crimes of sorcery and the possession of a demon were savagely ferocious. Perpetual imprisonment with confiscation of property was the mildest punishment. It required but little to have the unfortunate suspects, or those denounced by petty vengeance, submitted to inquiry, and be strangled and burned and their ashes thrown to the winds. The parliament of Lorraine, by the sentences commented upon by Nicolas Remy, procurer general, whose work appeared in 1595, took the lives of more than nine hundred persons for the crime of sorcery, in the space of fifteen years. We have before our eyes a small volume by Mr. Albert Denis upon sorcery at Toul, in the 16th century. In this, we find a collection of the most iniquitous sentences against unfortunates who to-day would be regarded as simply disordered and worthy of interest and compassion, and amenable to various therapeutic remedies.

According to popular belief, every individual possessed of a demon was marked with the claw of the devil. The nævi of the hysterical, the spontaneous ecchymoses that are observed among some of them, and, less than that, blotches and scars wholly accidental, were so many proofs of a compact made with the evil spirit. The symptom of anæsthesia, too, was one of the most convincing of proofs. What would these fanatical dispensers of justice have said had they been witness of the phenomena exhibited by the subjects of whom we are to speak; if they had seen any word whatever, the name of the devil if you please, inscribed upon the body of the accused by a pressure of the finger—Satan or demon in conspicuous letters upon the surface of the skin? The demonstration of guilt would have been more certain and more capital still, and condemnation to the gibbet or to fire would not have failed to be the fate of the sorcerer. Ten years ago, Mr. Dujardin-Beaumetz presented to the Societe Medicale des Hôpitaux a curious case, whose history very soon went the rounds of the press under the caption of the Stereotype-woman. The skin of this woman became red at the least contact. If a pencil or a dull point was passed over the skin, the lines or words traced were at once seen to appear in relief and with surprising distinctness.

This phenomenon, which was unique, or nearly so, at the time that Mr. Dujardin-Beaumetz communicated his observation, has been observed a certain number of times since. For his part, Dr. Mesnet has observed four of the clearest cases, and it is one of these

that furnished the subject of the photograph that we reproduce herewith.

Autographism (we retain the name given to this phenomenon by Dr. Mesnet) has been called also graphic urticaria, desmography, etc. (Dr. Féré).

The phenomenon consists in the appearance of a relief from the skin as a consequence of the presence of any object whatever—wrinkles in the shirt, pressure of the nail, finger, or a blunt point. The following is a very perspicuous description, by Dr. Mesnet, of the phenomenon, as it was produced upon the subject whose back bears in relief the inscription LA NATURE.

If, says he, we take a blunt style or a sharp-pointed pencil, and inscribe upon the shoulders, breast, arms, or thighs, a word, name, or figure, by moving the instrument lightly over all the figurative points of the word or inscription that we wish to produce, we shall almost instantly observe a redness to appear upon the line that the instrument has passed over. This diffused redness constitutes the first phase of the phenomenon. Two minutes later, the letter or inscription begins to appear under the form of a rosy-white outline of a much paler tint than the rubiolic erythema which surrounds it on all sides. Do not leave the patient, but watch the different phases of the experiment, and you will see the inscription complete itself before your eyes; you will see it extend, rapidly enlarge, take on a more and more prominent relief, rounded at the summit, and attain the size of half a goose quill applied to the skin.

When the phenomenon has reached its complete development, when the relief is well established, the part of the skin upon which the word or figure was delineated assumes exactly the appearance of a stereotype plate, whence the name of the stereotype-woman bestowed upon the first subject.

This relief, of which a picture can give but a feeble imitation, is visible from a distance of from thirty to sixty feet, and, according to the subject, lasts from a few minutes to several hours. It is a transitory phenomenon, in the sense that, in a few hours, the skin will have assumed its usual appearance; but it can be reproduced at will, and, in these subjects, the same impressionability of the skin may be observed for years. Autographism persists like all the other nerv-

THE PHENOMENON OF AUTOGRAPHISM.

ous disturbances that it accompanies in the subject. Dr. Mesnet has subjects whom he has been watching for four years—one for six years—and the autographism exhibits itself, every time, under pressure, as distinctly as it did when it was first observed. From what the subjects say, the skin reliefs vary at different seasons of the year, and appear with much greater intensity in the spring, in the same way that at certain periods the excitation of the nervous system is, for one cause or another, more pronounced.

Is it possible to interfere with the phenomenon of autographism by a local means? A certain number of experiments have been tried in this regard. Anæsthesia by sprays of ether and applications of ice momentarily prevents the appearance of the marks; but, as soon as the anæsthetic action has disappeared, the existence of the reliefs is shown as well as upon a point not anæsthetized. There is but a simple retardation in the evolution of the phenomenon. On the contrary, anæsthesia proper of the subjects in no wise modifies it. Prick the left side of the subject who is shown in our engraving, and she will not feel it at all; on the contrary, the right side is perfectly sensitive. The pencil moved over the two sides causes the appearance of the autographic "stereotypes" equally well, with the difference that at the right the subject feels the motion of the pencil, and, at the left, does not feel it at all.

What is the cause of this singular phenomenon? Is it a question of a variety of urticaria? Every one knows the very disagreeable and even painful eruption caused by contact with the nettle. Now a similar eruption appears upon many people without any well determined cause—sometimes through eating mussels, craw fish, strawberries, etc. Is there something identical here? There is no itching, as in urticaria, and, although some subjects have sometimes had eruptive rashes of this kind, the coexistence at other times is entirely absent.

It appears reasonable, therefore, to connect autographism with manifestations of a nervous order, with those functional troubles that we meet with in nervous people, and especially in hysteria. Most of the subjects in whom this phenomenon has been observed are, in fact, profoundly hysterical. We say *most*, for Dr. Féré has observed it in epileptics likewise. Some have an anæsthesia of several parts of the body; others have functional disorders of the sense organs—color blindness, diminution of the visual field, perversions of taste, etc.; and others exhibit characteristic nervous crises. Dr. Mesnet's four subjects were, moreover, very easily hypnotizable by the usual means—fixation of a metallic object, of the finger, etc. This susceptibility to hypnotization has led the learned clinical physician to an ingenious theory of the pathogeny of autographism. He asks himself whether one can conceive of a relation between these peripheric vasomotor disturbances and the dynamic perturbations that accompany hypnotism. "Has" (asks he) "the external phenomenon of capillary circulation that takes place before our eyes in autographism its congener in an intimate and profound disturbance of the capillary circulation of the brain—a disturbance that we cannot ascertain *de visu*, but the effects of which are shown to us by the momentary dissociation in the exercise of the intellectual faculties? The question, evidently, can merely be asked. Whatever be the exact interpretation of this singular cutaneous manifestation, it is none the less interesting, and worthy, we think, of the attention of our readers.—*Dr. A. Cartaz, in La Nature.*

KOLA NUT FOR SEASICKNESS.

DR. C. W. HAMILTON, of the British navy, writes to the *British Medical Journal* that he has found the seed of the kola (*Sterculia acuminata*) a most successful remedy in seasickness. From half to one drachm of the seed was slowly chewed, and in about half an hour the distressing symptoms of the malady gradually disappeared. The writer had never found any drug to act as well as this, and believes that further trials will prove it to be an effectual remedy for seasickness.

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